PTO/SB/08a (07-09)
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	1	of	2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2629
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner Initial *	Cite No.	Document Number Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-3,623,867	11-30-1971	Saulnier	
	2	US-3,842,306	10-15-1974	Henderson et al.	
	3	US-5,640,216	06-17-1997	Hasegawa et al.	
	4	US-5,670,797	09-23-1997	Okazaki	
	5	US-5,818,677	10-06-1998	Kurematsu et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents, at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

Substitute for form 1449B/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	12/559,042
	Filing Date	09-14-09
	First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)	Art Unit	2829
	Examiner Name	Raj R. Gupta
Sheet 2 of 2	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Cite No. [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
	6	U.S. Office Action issued in co-pending application 12/548,614 on June 27, 2011.	
	7	U.S. Office Action issued in co-pending application 12/689,681 on June 23, 2011.	

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicant's unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

Electronic Acknowledgement Receipt

EFS ID:	10677633
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	02292
Filer:	David Richard Anderson/Patti Young
Filer Authorized By:	David Richard Anderson
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	05-AUG-2011
Filing Date:	14-SEP-2009
Time Stamp:	15:19:29
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20110805IDS.pdf	3312913 c6d981625844ce9070652e6bace98ca835a94bd3	yes	7

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	5
	Information Disclosure Statement (IDS) Form (SB08)	6	7

Warnings:

Information:

2	Non Patent Literature	USOA12548614dated062711.pdf	5353614 19bdacb960e9fe8a1497b836e44f1825d480087b	no	13

Warnings:

Information:

3	Non Patent Literature	USOA12689681dated062311.pdf	3258201 253966f1ff94f142b40885a0d3a34b95aaa5d7bc	no	8

Warnings:

Information:

Total Files Size (in bytes):	11924728

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Yoshinori SHIMIZU et al.

Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. Copies of foreign patent documents, non-patent literature and other information.

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date

12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☐ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

U.S. 3,623,867, U.S. 3,842,306 and U.S. 5,816,677 were cited in a U.S. Office Action issued in co-pending application 12/689,681 on June 23, 2011; and U.S. 5,670,797 and U.S. 5,640,216 were cited in a U.S. Office Action issued in co-pending application 12/548,614 on June 27, 2011.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS.

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

V. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VI. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: August 5, 2011

Respectfully submitted,

By

D. Richard Anderson
Registration No.: 40,439
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8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☐ Other:

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

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12/028,062 filed February 8, 2008

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☑ c. OTHER: The following additional information is provided.

The publication by Yao Go submitted herein was cited in the Request for Invalidation of Chinese Patent No. 03159595.2 submitted herein. Chinese Patent No. 03159595.2 is a counterpart foreign application of the present US application. The Request for Invalidation submitted herein was submitted to the Chinese Patent Office by a third party and then the Chinese Patent Office dispatched a Notification of Acceptance of Request for Invalidation, submitted herein, for informing the fact that a third party submitted a Request for Invalidation.

A concise explanation regarding publication by Yao Go and the Request for Invalidation is submitted herein, as follows. The publication by Yao Go cited in the Request for Invalidation is alleged to describe that a crystal structure of the garnet will have a defect and a light emitting characteristics will be suddenly changed if all Y is replaced with Gd. This concise explanation corresponds to a portion of the publication by Yao Go cited in the Request for Invalidation.

cet

All references discussed and cited in the US Office Action of co-pending Appl. No. 12/575,155 submitted herein were previously submitted to USPTO.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

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☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this

IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

V. FEES

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☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)). cet

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

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☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: November 10, 2011

Respectfully submitted,

By ______________________

D. Richard Anderson
Registration No.: 40439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

cet

☑ PTO/SB/08
☑ Document(s)
☐ Foreign Patent Office Communication
☐ Foreign Search Report
☐ Fee
☑ Other: (1) Request for Invalidation with Notification of Acceptance of Request for Invalidation of Chinese Patent No. 03159595.2 dispatched on August 10, 2011.
(2) Office Action issued in co-pending US Appl. No. 12/575,155 on September 30, 2011.

PTO/SB/08b (07-09)
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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

Sheet 1 of 1

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Office Action issued in co-pending US Appl. No. 12/575,155 on September 30, 2011.	☐
	2	Request for Invalidation with Notification of Acceptance of Request for Invalidation of Chinese Patent No. 03159595.2 dispatched on August 10, 2011.	☐
	3	Yao Go et al., Synthesis and Luminescence Gallium Nitride LED Blue Light Conversion Materials, ACTA PHYSICO-CHIMICA SINICA, Vol.19, No.3, March 2003, p226 – 229.	☑
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Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

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Electronic Acknowledgement Receipt

EFS ID:	11383107
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	David Richard Anderson
Filer Authorized By:	
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	10-NOV-2011
Filing Date:	14-SEP-2009
Time Stamp:	17:47:02
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	IDS_SB08.pdf	259088 db48274cd35ec24c66ef488d0eee3221e56dd7a7	no	6

Warnings:

Information:

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2	Non Patent Literature	IDSUSOA_12575155_dated_2011-09-30.pdf	708084 d0c257dbb4b398b06ac2264a835c05dd357858c3	no	13
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Information:					
3	Non Patent Literature	IDSNotice_Of_Acceptance_Of_Request_For_Invalidation_CN031595952.pdf	1357114 7c761b4264449ec7aa355f0a80a88cb2f269e084	no	30
Warnings:					
Information:					
4	Non Patent Literature	IDSNPL_YaoGo_2384305.pdf	559568 89e6e59ca0678accec4b6ad1b52d1d7ef08c85d0	no	8
Warnings:					
Information:					
		Total Files Size (in bytes):	2883854		

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New Applications Under 35 U.S.C. 111

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	12/559,042
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				Examiner Name	Raj R. Gupta
Sheet	1	of	1	Attorney Docket Number	0020-5147PUS7

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Examiner Initial *	Cite No. [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
	1	US Office Action issued in co-pending application no. 12/669,681 on December 5, 2011.	

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.
This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Cheif Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450 Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	11819270
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/Patti Young
Filer Authorized By:	Corina E. Tanasa
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	12-JAN-2012
Filing Date:	14-SEP-2009
Time Stamp:	12:08:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20120112IDS.pdf	2503179 9cf304cd1fc092c5fb2ee6553f97c009f4bc6d20	yes	6

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	5
	Information Disclosure Statement (IDS) Form (SB08)	6	6

Warnings:

Information:

2	Non Patent Literature	USOA12689681dated120511.pdf	5936389 df8ac013aec112a9e180d967d9157bb121b2b32e	no	12

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Information:

Total Files Size (in bytes):	8439568

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of: Yoshinori SHIMIZU et al.			
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. Copies of foreign patent documents, non-patent literature and other information.

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date
12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☐ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A U.S. Office Action issued in co-pending application 12/689,681 on December 5, 2011 is attached. The references discussed in the Office Action were previously submitted to the USPTO in IDS.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VI. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: January 12, 2012

Respectfully submitted,

By Corina Tanasa Reg. No 64,042

for D. Richard Anderson CORINA TANASA
Registration No.: 40,439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):
- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☐ Other:

PTO/SB/08a (07-09)
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number: Number - Kind Code 2 (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2006/0067668 - A1	03-30-2006	KITA	
	2	US-2008/0128735 - A1	06-05-2008	YOO et al.	
	3	US-5,966,393 - A	10-12-1999	HIDE et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country Code 3	Number 4 Kind Code (if known) 5	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	4	JP	9-116225 - A	05-02-1997			✓

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450 Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

wt

Substitute for form 1449B/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				**Application Number**	12/559,042
				Filing Date	09-14-09
				First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)				Art Unit	2829
				Examiner Name	Raj R. Gupta
Sheet	2	of	2	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
	5	U.S. Office Action, dated January 30, 2012, for U.S. Application No. 12/942,792.	
	6	U.S. Office Action, dated January 9, 2012, for U.S. Application No. 12/947,470.	
	7	U.S. Office Action, dated March 13, 2012, for U.S. Application No. 13/210,027.	

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

cet

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

LETTER REGARDING COPENDING APPLICATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Under the provisions of MPEP § 2001.06(b), the Examiner is hereby advised of the following copending U.S. Application:

Appl. No.	Filing Date	Group
13/210,027	August 15, 2011	2812

The subject matter contained in the above-listed copending U.S. application may be deemed to relate to the present application, and thus may be material to the prosecution of this instant application.

The above-listed co-pending application is not to be construed as prior art. By bringing the above-listed application to the attention of the Examiner, Applicants do NOT waive any confidentiality concerning the above-listed co-pending application or this application. See MPEP § 101.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: APR 5 2012

Respectfully submitted, Reg. No

By Corina Tanasa 64042

for D. Richard Anderson

Registration No.: 40439 CORINA TANASA

BIRCH, STEWART, KOLASCH & BIRCH, LLP
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Falls Church, VA 22040-0747
703-205-8000

Electronic Acknowledgement Receipt

EFS ID:	12466472
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/Sarah Beatty (ts)
Filer Authorized By:	Corina E. Tanasa
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	05-APR-2012
Filing Date:	14-SEP-2009
Time Stamp:	12:40:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Non Patent Literature	JP-9-116225-AwithTranslation.pdf	2962797 612782c545a54da452bac5e2cf2f1a020d042a3c	no	13

Warnings:

Information:

2	Non Patent Literature	USOAdated01-30-2012forApln 12-942792.pdf	1856035 4c272c8055a98bf157c96c8ec006aaad8448df38	no	31
Warnings:					
Information:					
3	Non Patent Literature	USOAdated01-09-2012forApln 12-947470.pdf	1845677 9cd4184837bbc1df98a6e065617756563dc1b108	no	30
Warnings:					
Information:					
4	Non Patent Literature	USOAdated03-13-2012forApln 13-210027.pdf	1774649 76f467abe4d4bcfd3c762368956e8ecd92393780	no	28
Warnings:					
Information:					
5		2012-04-05_IDSTransmittals_0020-5147PUS7.pdf	353351 3af1269db82bf404275645e95ad72b19840e6087	yes	7

Multipart Description/PDF files in .zip description

Document Description	Start	End
Transmittal Letter	1	5
Information Disclosure Statement (IDS) Form (SB08)	6	7

Warnings:					
Information:					
6	Miscellaneous Incoming Letter	2012-04-05_CopendingLetter_0020-5147PUS7.pdf	51092 9e20a94a190598c4ac21d9aee14d4f9f3bf5144e	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	8843601	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 09-116225
(43)Date of publication of application : 02.05.1997

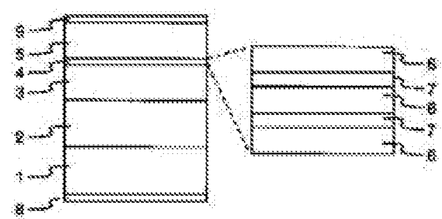
(51)Int.Cl. H01S 3/18

(21)Application number : 07-272321
(22)Date of filing : 20.10.1995

(71)Applicant : HITACHI LTD
(72)Inventor : NIWA ATSUKO
OTOSHI SO
KURODA TAKARO
TANAKA TOSHIAKI
WATANABE AKISADA

(54) SEMICONDUCTOR LIGHT EMITTING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce the threshold carrier density of a gallium nitride-based compound semiconductor laser by reducing the state density of a valence band and increasing the transition probability of the band.
SOLUTION: A quantum well active layer 4 having a biaxial tensile strain is grown on a substrate crystal 1 having plane orientation of (1-100)-plane, (11-20)-plane, or an equivalent plane, and a resonator is constituted in the direction perpendicular to the (0001)-direction. Therefore, the state density of the upper part of a valence band can be reduced and, at the same time, the transition probability of the band can be increased. In addition, a gallium nitride-based compound semiconductor laser can be obtained, because the threshold current density can be reduced.



CLAIMS

[Claim(s)]
[Claim 1]A semiconductor light emitting element comprising material whose grating constant in the state characterized by comprising the following where it is formed on a field or a field equivalent to this, and optically biaxial stress does not have a well layer of the above-mentioned quantum well active layer is smaller than a grating constant of the first crystal of the above.
It is a cladding layer of a bilayer of the first conductivity type and the second conductivity type on the first crystal that comprises a compound semiconductor at least and has wurtzite structure.
It is a semiconductor light emitting element which grows epitaxially a quantum well active layer inserted into the above-mentioned cladding layer, and the above-mentioned quantum well active layer is a gap of less than 10 degrees from a field (1-100).

[Claim 2]A semiconductor light emitting element comprising material whose grating constant in the state characterized by comprising the following where it is formed on a field or a field equivalent to this, and optically biaxial stress does not have a well layer of the above-mentioned quantum well active layer is smaller than a grating constant of the first crystal of the above.
It is a cladding layer of a bilayer of the first conductivity type and the second conductivity type on the first crystal that comprises a compound semiconductor at least and has wurtzite structure.
It is a semiconductor light emitting element which grows epitaxially a quantum well active layer inserted into the above-mentioned cladding layer, and the above-mentioned quantum well active layer is a gap of less than 10 degrees from a field (11-20).

[Claim 3]A semiconductor light emitting element, wherein a waveguide is formed in the direction vertical to the [0001] directions in a semiconductor light emitting element given in the 1-2nd clauses of a range of claim for patent.
[Claim 4]A semiconductor light emitting element, wherein the above-mentioned quantum well active layer is constituted from InxGayAl1-x-yNzAs1-z (0< x<=1, 0< y<=1, 0< z<=1) in a semiconductor light emitting element of a description by the 1-3rd clauses of a range of claim for patent.
[Claim 5]A semiconductor light emitting element, wherein the first crystal of the above is growing epitaxially on a ZnO board in a semiconductor light emitting element of claim for patent given in the 1-4th clauses of a range.
[Claim 6]A semiconductor light emitting element characterized by oscillation wavelengths being 350 nm - 550 nm in a semiconductor light emitting element of claim for patent given in the 1-5th clauses of a range.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the light emitting device which used the gallium nitride system compound semiconductor.
[0002]
[Description of the Prior Art]Gallium nitride system compound semiconductors, such as GaN, GaAlN, InGaN, and InGaAlN, are wide gap semiconductors which have a transited [directly] type, and are actively studied as a material which constitutes the light emitting device to an ultraviolet area from blue. The present, As a light emitting device using this material. The high-intensity blue LED of the double hetero structure which makes a luminous layer Zn dope InGaN layer constituted on silicon on sapphire is known (S. Nakamura et al., Appl. Phys. Lett., 64 (1994) 1687). The gallium nitride system light emitting device which constituted on the ZnO board and decreased the defect by a lattice strain is indicated by the JP,5-206513,A gazette. However, gallium nitride system compound semiconductor laser by current injection was not realized until now.
[0003]
[Problem to be solved by the invention]That the laser oscillation by current injection is difficult in a gallium nitride system compound semiconductor originates in the density of states of the valence band of this material system being large, and threshold carrier density being high. The band structure of the valence-band upper part near gamma point in case [of wurtzite type GaN / distorted] there is nothing is shown in drawing 5.
[0004]Incidentally, gamma point is a point that wave number vector k (equivalent to the wave number of the horizontal axis of drawing 5) of the electron inside a crystal is set to "0." Now, in a wurtzite type semiconductor, the split of the energy of gamma point is carried out to three by the crystal field and a spin orbit interaction. In the state of the wave function of gamma point, these three bands are made for convenience to be referred to as hh(heavy hole)1, hh2, and lh (light hole), respectively. The threshold carrier density which the density of states of the valence-band upper part of GaN gives laser oscillation since it is large as compared with common III-V fellows semiconductors, such as GaAs, increased, and the laser oscillation by current injection was difficult. In a wurtzite type semiconductor, since the character of the wave function of hh1 and hh2 is the same, even if it adds distortion, the energy split of hh1 and hh2 hardly changes. For this reason, with a wurtzite type semiconductor, reduction of the density of states by a compressive strain was not able to be expected, either.
[0005]According to the reduction of the density of states of the valence-band upper part and the increase of optical transition probability by the hauling distortion of a gallium nitride system compound semiconductor, this invention reduces threshold carrier density required for laser oscillation, and an object of this invention is to realize the gallium nitride semiconductor laser by current injection.
[0006]
[Means for solving problem]The gallium nitride system semiconductor light emitting device of this invention grows the quantum well active layer which has an optically biaxial hauling distortion on

the field (1−100) of the first crystal with wurtzite structure, and produces a waveguide in a direction vertical to the [0001] axes of the 1st crystal, i.e., the [11−20] direction. The same effect can be acquired also by growing up the active layer which has an optically biaxial hauling distortion on the field (11−20) of the first crystal, and producing a waveguide in a direction vertical to [0001] axes, i.e., the [1−100] direction. The same effect can be acquired also when the plane direction of the first above-mentioned crystal is a field which has a gap of (1−100) or (11−20) to 10 degrees. If it puts in another way, to the surface of a substrate in which an element is formed, the semiconductor light emitting element by this invention has the almost parallel c axis of the crystal which constitutes (1) active layer, and it pulls it to the well layer of (2) active layers, and it has the structural feature that distortion is added.
[0007]For example, the band structure of the valence-band upper part near gamma point at the time of adding 2% of optically biaxial hauling distortion to wurtzite type GaN becomes like drawing 6. By impressing hauling distortion as compared with drawing 5 shows that lh band which consists of a z orbit shifts to the upper part, and the density of states of the valence-band upper part of a direction parallel to c axis, i.e., [0001] axes, decreases substantially. That is, change of the energy (vertical axis) over the wave number (horizontal axis) of a direction parallel to c axis becomes sudden, and density of states is decreasing. Therefore, the density of states of a valence band can be reduced by constituting a quantum well active layer on a direction vertical to [0001] axes, i.e. (1−100), a field, a field, or a field equivalent to this, and considering it as the structure which impressed hauling distortion.
[0008]When a quantum well is formed on a field (1−100) or (11−20) a field, optical transition probability has a polarization direction dependency with quantum well side Uchi's anisotropy. For example, the polarization dependency of the transition-matrix element in gamma point of a quantum well that a plane direction is (1−100) becomes as it is shown in Table 1 as compared with the case of the distortionless quantum well constituted in the field (0001). Table 1 shows the calculation result of the optical matrix element in the band end in a GaN quantum well.
[0009]
[Table 1]
表1

基板面 / 偏光	(0001) 無歪	(1-100) 2%引っ張り歪
TEモード	7.62 eV	13.2 eV (偏光 [0001])
		0.92 eV (偏光 [11-20])
TMモード	0 eV	1.05 eV

[0010]Table 1 shows that transition probability can be enlarged about 2 times in the hauling distortion quantum well on a field (1−100), if a waveguide is formed in a direction vertical to [0001], i.e., the [11−20] direction, (the energy value in front shows the ease of producing of optical transition, and transition probability is so high that it is large). By this, a gain increases, threshold carrier density required for an oscillation is reduced, and a gallium nitride semiconductor laser can be realized.
[0011]
[Mode for carrying out the invention]The first working example of this invention is described using drawing 1.
[0012]This multiplex quantum well laser like a graphic display on the field (1−100) n type ZnO board 1, InGaN buffer layer 2 which carries out lattice matching to the substrate 1, n-InGaAlN layer 3 which doped Si, the active layer 4 which consists of an undoping multiplex quantum well, and p-InGaAlN layer 5 which doped Mg are laminated successively, and is constituted. These

each layers grow epitaxially with a gas source molecular beam grown method. The thickness of the buffer layer 2, n-InGaAlN layer 3, and p-InGaAlN layer 5 is 2 micrometers, 0.15 micrometer, and 0.15 micrometer, respectively. The undoping multiplex quantum well active layer 4 has the double quantum well structure where the $In_{0.2}Ga_{0.6}aluminum_{0.2}N$ barrier layer (8 nm of thickness) 6 and the $In_{0.1}Ga_{0.9}N$ well layer (4 nm of thickness) 7 were laminated by turns, as expanded and shown. The composition ratio of the well layer 7 is set up here so that gap deltaa/a of a future grating constant may be -1.8%, when the grating constant of ZnO is set to a, and an optically biaxial hauling distortion is impressed. After vapor-depositing the n side In electrode 8 at the rear face of the substrate 1 of the wafer produced by making it above and vapor-depositing Al electrode 9 to the p type InGaAlN layer 5, a cleavage is carried out a field (11-20), a resonator about 800 micrometers in length is formed in the [11-20] direction (side side of the active layer 4 of drawing 1), and a semiconductor laser is produced. In the room temperature, continuous oscillation of this semiconductor laser was carried out with about 50 mA of threshold current. The oscillation wavelength was about 420 nm.

[0013]In this example, the plane direction of the ZnO board was made into the field (11-20), and when the semiconductor laser which formed the resonator in the [1-100] direction was produced similarly, what has almost equivalent threshold current and oscillation wavelength was obtained. In this example, the plane direction of the ZnO board was made into Men who inclined 10 degrees in the [0001] directions from the field (1-100), and when the semiconductor laser which formed the resonator in the [11-20] direction was produced similarly, what has almost equivalent threshold current and oscillation wavelength was obtained.

[0014]Next, the second working example of this invention is described using drawing 2.

[0015]The presentation x of In1-xGaxN grown-up on the field (1-100) n type ZnO board 1 like a graphic display on the InGaN presentation inclined layer 11 which changes continuously from 0.8 to 0.5, The $In_{0.5}Ga_{0.5}N$ buffer layer 12 which carries out lattice matching to the presentation inclined layer 11, n-InGaAlN layer 13 which doped Si, the active layer 14 which consists of an undoping multiplex quantum well, and p-InGaAlN layer 15 which doped Mg are laminated successively, and is constituted. These each layers grow epitaxially with a gas source molecular beam grown method. The thickness of the buffer layer 12, n-InGaAlN layer 13, and p-InGaAlN layer 15 is 2 micrometers, 0.15 micrometer, and 0.15 micrometer, respectively. The undoping multiplex quantum well active layer 14 has the double quantum well structure where the $In_{0.35}Ga_{0.5}aluminum_{0.15}N$ barrier layer (5 nm of thickness) 16 and the $In_{0.2}Ga_{0.8}N$ well layer (3 nm of thickness) 17 were laminated by turns, as expanded and shown. The composition ratio of the well layer 17 is set up here so that gap deltaa/a of a future grating constant may be -2.0%, when the grating constant of an $In_{0.5}Ga_{0.5}N$ buffer layer is set to a, and an optically biaxial hauling distortion is impressed. After vapor-depositing the n side In electrode 8 at the rear face of the substrate 1 of the wafer produced by making it above and vapor-depositing Al electrode 9 to the p type InGaAlN layer 5, a cleavage is carried out a field (11-20), a resonator about 800 micrometers in length is formed in the [11-20] direction, and a semiconductor laser is produced. In the room temperature, continuous oscillation of this semiconductor laser was carried out with about 60 mA of threshold current. The oscillation wavelength was about 450 nm.

[0016]Although InGaN was used as a quantum well layer and ZnO was used as a substrate in the above-mentioned working example, composition used for the light emitting device of this invention can be considered as the composition which is not limited to this, for example, is shown in drawing 3 - drawing 4.

[0017]The semiconductor laser shown in drawing 3 on the field (1-100) of the n type ZnO board 1, InGaN buffer layer 2 which carries out lattice matching to the substrate 1 grows, and on this buffer layer 2, n-InGaAlN layer 3, the undoping single quantum well active layer 21, and the p-InGaAlN cladding layer 5 are laminated successively, and are constituted. These each layers grow epitaxially with a gas source molecular beam grown method. The quantum well active layer 21 has here the single quantum well structure where the $GaN_{0.95}As_{0.05}$ well layer (5 nm of thickness) 22 was inserted into the $In_{0.2}Ga_{0.6}$aluminum$_{0.2}$N barrier layer (10 nm of thickness) 23, as expanded and shown. The composition ratio of the well layer 22 is set up here so that gap deltaa/a of a future grating constant may be −1.8%, when the grating constant of ZnO is set to a, and an optically biaxial hauling distortion is impressed. After vapor-depositing the n side In electrode 8 at the rear face of the substrate 1 of the wafer produced by making it above and vapor-depositing Al electrode 9 to the p type InGaAlN layer 5, a cleavage is carried out a field (11−20), a resonator about 800 micrometers in length is formed in the [11−20] direction, and a semiconductor laser is produced. In the room temperature, continuous oscillation of this semiconductor laser was carried out with about 50 mA of threshold current. The oscillation wavelength was about 450 nm.

[0018]On the field (1−100) of the silicon on sapphire 31, InGaN buffer layer 2 grows, n-InGaAlN layer 3, the undoping multiplex quantum well active layer 4, and the p-InGaAlN cladding layer 5 are laminated successively, and the semiconductor laser shown in drawing 4 is constituted at this buffer layer 2 top. These each layers grow epitaxially by metal-organic chemical vapor deposition. The quantum well active layer 4 has here the multiple quantum well structure by which the $In_{0.2}Ga_{0.6}$aluminum$_{0.2}$N barrier layer (8 nm of thickness) 6 and two cycles of $In_{0.1}Ga_{0.9}N$ well layers (4 nm of thickness) 7 were laminated by turns, as expanded and shown. The composition ratio of the well layer 7 is set up here so that gap deltaa/a of a future grating constant may be −1.8%, when the grating constant of an InGaN buffer layer is set to a, and an optically biaxial hauling distortion is impressed. A part of p-InGaAlN cladding layer 5 of a wafer and quantum well active layer 4 produced by making it above are removed by etching, After exposing the n-InGaAlN cladding layer 3 and vapor-depositing Al electrode 9 to p-cladding layer and n-cladding layer, a cleavage is carried out a field (11−20), a resonator about 800 micrometers in length is formed in the [11−20] direction, and a semiconductor laser is produced. In the room temperature, continuous oscillation of this semiconductor laser was carried out with about 70 mA of threshold current. The oscillation wavelength was about 420 nm.

[0019]This invention is applicable not only to the laser structure shown in the working example but various semiconductor lasers, for example, a distributed feedback laser, a distributed Bragg reflector laser, tunable laser, and laser with an external resonator.

[0020]

[Effect of the Invention]As mentioned above, the gallium nitride system compound semiconductor light emitting device of this invention, Since a plane direction grows the quantum well active layer which has an optically biaxial hauling distortion on the base substance crystal which is a field (1−100) or (11−20) a field and is producing the waveguide in the direction vertical to the [0001] directions, transition probability can be small increased in the density of states of the valence-band upper part. Since a gain increases and threshold current density can be reduced by this, gallium nitride system compound semiconductor laser is realizable.

[0021]

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The block diagram of the semiconductor laser of this invention working example.
[Drawing 2]The block diagram of the semiconductor laser of this invention working example.
[Drawing 3]The block diagram of the semiconductor laser of this invention working example.
[Drawing 4]The block diagram of the semiconductor laser of this invention working example.
[Drawing 5]The figure showing the energy dispersion of the valence-band upper part of wurtzite type GaN in case [distorted] there is nothing. .
[Drawing 6]The figure showing the energy dispersion of the valence-band upper part of wurtzite type GaN at the time of impressing optically biaxial hauling distortion 2%.
[Explanations of letters or numerals]
1 -- (1-100) field n type ZnO board, 2 -- InGaN buffer layer, 3 -- n-InGaAlN layer, 4 -- undoping multiplex quantum well active layer, 5 -- p-InGaAlN layer, 6 -- $In_{0.2}Ga_{0.6}aluminum_{0.2}N$ barrier layer, 7 -- $In_{0.1}Ga_{0.9}N$ well layer, 8 -- In electrode, 9 -- Al electrode, 11 -- InGaN presentation inclined layer, 12 -- $In_{0.5}Ga_{0.5}N$ buffer layer, 13 -- n-InGaAlN layer, 14 -- undoping multiplex quantum well active layer, 15 -- p-InGaAlN layer, 16 -- $In_{0.35}Ga_{0.5}aluminum_{0.15}N$ barrier layer, 17 -- $In_{0.2}Ga_{0.8}N$ well layer, 21 -- undoping single quantum well active layer, 22 -- $GaN_{0.95}As_{0.05}$ well layer, 23 -- $In_{0.2}Ga_{0.6}aluminum_{0.2}N$ barrier layer, 31 -- silicon on sapphire.

[Translation done.]

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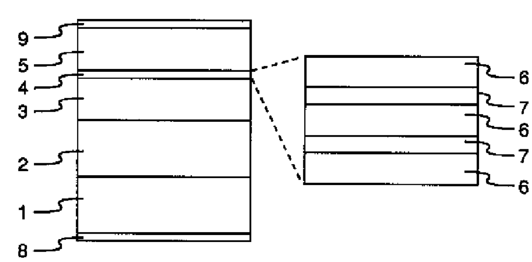
最終頁に続く

(54)【発明の名称】　半導体発光素子

(57)【要約】
【課題】窒化ガリウム系化合物半導体レーザでは、価電子帯の状態密度低減と遷移確率増大によるしきい値キャリア密度の低減が必要であった。
【解決手段】面方位が（１－１００）面、あるいは（１１－２０）面、あるいはこれと等価な面である基体結晶上に二軸性の引っ張り歪をもつ量子井戸活性層を成長し、共振器を［０００１］方向に垂直な方向に作製する。
【効果】本発明によれば、価電子帯上部の状態密度を低減し、かつ、遷移確率を増大できる。これにより、しきい値電流密度を低減できるため、窒化ガリウム系化合物半導体レーザを実現できる。

図１



【特許請求の範囲】

【請求項１】少なくとも化合物半導体で構成され、ウルツ鉱構造をもつ第一の結晶上に、第一導電型及び第二導電型の二層のクラッド層と、上記クラッド層に挟まれた量子井戸活性層をエピタキシャル成長してなる半導体発光素子であって、上記量子井戸活性層が（１－１００）面から１０度以内のずれを有する面、あるいはこれと等価な面上に形成されており、上記量子井戸活性層の井戸層が、二軸性応力の無い状態での格子定数が上記第一の結晶の格子定数より小さい材料で構成されていることを特徴とする半導体発光素子。

【請求項２】少なくとも化合物半導体で構成され、ウルツ鉱構造をもつ第一の結晶上に、第一導電型及び第二導電型の二層のクラッド層と、上記クラッド層に挟まれた量子井戸活性層をエピタキシャル成長してなる半導体発光素子であって、上記量子井戸活性層が（１１－２０）面から１０度以内のずれを有する面、あるいはこれと等価な面上に形成されており、上記量子井戸活性層の井戸層が、二軸性応力の無い状態での格子定数が上記第一の結晶の格子定数より小さい材料で構成されていることを特徴とする半導体発光素子。

【請求項３】特許請求の範囲第１～２項に記載の半導体発光素子において、［０００１］方向と垂直な方向に導波路が形成されていることを特徴とする半導体発光素子。

【請求項４】特許請求の範囲第１～３項に記載の半導体発光素子において、上記量子井戸活性層が$InxGayAl_{1-x-y}N_zAs_{1-z}$（$0<x\leqq1$、$0<y\leqq1$、$0<z\leqq1$）で構成されていることを特徴とする半導体発光素子。

【請求項５】特許請求の範囲第１～４項記載の半導体発光素子において、上記第一の結晶がＺｎＯ基板上にエピタキシャル成長されていることを特徴とする半導体発光素子。

【請求項６】特許請求の範囲第１～５項記載の半導体発光素子において、発振波長が３５０ｎｍ～５５０ｎｍであることを特徴とする半導体発光素子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は窒化ガリウム系化合物半導体を用いた発光素子に関する。

【０００２】

【従来の技術】ＧａＮ、ＧａＡｌＮ、ＩｎＧａＮ、ＩｎＧａＡｌＮ等の窒化ガリウム系化合物半導体は直接遷移型を有するワイドギャップ半導体であり、青色から紫外域までの発光素子を構成する材料として盛んに研究されている。現在、この材料を用いた発光素子としてサファイア基板上に構成したＺｎドープＩｎＧａＮ層を発光層とするダブルヘテロ構造の高輝度青色ＬＥＤが知られている(S. Nakamura et al., Appl. Phys. Lett., 64(1994) 1687)。また、ＺｎＯ基板上に構成し格子歪による欠陥を減少した窒化ガリウム系発光素子が特開平５－２０６５１３公報に開示されている。しかし、これまで電流注入による窒化ガリウム系化合物半導体レーザは実現されていなかった。

【０００３】

【発明が解決しようとする課題】窒化ガリウム系化合物半導体において電流注入によるレーザ発振が困難であるのは、この材料系の価電子帯の状態密度が大きく、しきい値キャリア密度が高いことに起因する。図５にウルツ鉱型ＧａＮの歪の無い場合のΓ点付近の価電子帯上部のバンド構造を示す。

【０００４】因みに、Γ点は結晶内部の電子の波数ベクトルｋ（図５の横軸の波数に相当）が「０」となる点である。さて、ウルツ鉱型半導体では、結晶場とスピン軌道相互作用によりΓ点のエネルギーは三つにスプリットする。この三つのバンドをΓ点の波動関数の状態で、便宜的に、それぞれｈｈ（ｈｅａｖｙ　ｈｏｌｅ）１、ｈｈ２、ｌｈ（ｌｉｇｈｔ　ｈｏｌｅ）と呼ぶことにする。ＧａＮの価電子帯上部の状態密度はＧａＡｓ等の一般的なＩＩＩ－Ｖ族半導体と比較して大きいため、レーザ発振を与えるしきい値キャリア密度が増大し、電流注入によるレーザ発振は困難であった。またウルツ鉱型半導体では、ｈｈ１とｈｈ２の波動関数の性質が同じであるため、歪を加えてもｈｈ１、ｈｈ２のエネルギースプリットはほとんど変化しない。このため、ウルツ鉱型半導体では圧縮歪による状態密度の低減も期待できなかった。

【０００５】本発明は窒化ガリウム系化合物半導体の引っ張り歪による価電子帯上部の状態密度の低減と光学遷移確率の増大により、レーザ発振に必要なしきい値キャリア密度を低減し、電流注入による窒化ガリウム系半導体レーザを実現することを目的とする。

【０００６】

【課題を解決するための手段】本発明の窒化ガリウム系半導体発光素子は、ウルツ鉱構造をもつ第一の結晶の（１－１００）面上に二軸性の引っ張り歪をもつ量子井戸活性層を成長し、導波路を第１の結晶の［０００１］軸に垂直な方向、すなわち［１１－２０］方向に作製することを特徴とする。また、第一の結晶の（１１－２０）面上に二軸性の引っ張り歪をもつ活性層を成長し、導波路を［０００１］軸に垂直な方向、すなわち［１－１００］方向に作製することによっても同様の効果を得ることができる。また、上記の第一の結晶の面方位が（１－１００）あるいは（１１－２０）から１０度以内のずれを有する面である場合にも同様の効果を得ることができる。換言すれば、本発明による半導体発光素子は、（１）活性層を構成する結晶のｃ軸が素子が形成される基板の表面に対して略平行であり、且つ（２）活性層の井戸層には引っ張り歪が加えられているという構造

的な特徴を有する。

【０００７】例えばウルツ鉱型ＧａＮに２％の二軸性引っ張り歪を加えた場合のΓ点付近の価電子帯上部のバンド構造は図６のようになる。図５と比較すると、引っ張り歪を印加することによりｚ軌道からなるｌｈバンドが上側にシフトしｃ軸すなわち［０００１］軸に平行な方向の価電子帯上部の状態密度が大幅に低減することがわかる。即ち、ｃ軸に平行な方向の波数（横軸）に対するエネルギ（縦軸）の変化が急となり、状態密度が低減している。したがって、量子井戸活性層を［０００１］軸に垂直な方向、すなわち（１－１００）面あるいは（１１－２０）面、またはこれと等価な面上に構成し、引っ＊張り歪を印加した構造とすることにより価電子帯の状態密度を低減することができる。

【０００８】また、（１－１００）面あるいは（１１－２０）面上に量子井戸を形成すると量子井戸面内の異方性により光学遷移確率は偏光方向依存性をもつ。例えば、面方位が（１－１００）である量子井戸のΓ点における遷移行列要素の偏光依存性は、（０００１）面に構成した無歪の量子井戸の場合と比較すると表１のようになる。表１は、ＧａＮ量子井戸におけるバンド端での光学行列要素の計算結果を示す。

【０００９】

【表１】

表１

基板面＼偏光	(0001) 無歪	(1-100) 2%引っ張り歪
TEモード	7.62 eV	13.2 eV (偏光 [0001])
		0.92 eV (偏光 [11-20])
TMモード	0 eV	1.05 eV

【００１０】表１より、（１－１００）面上の引っ張り歪量子井戸では導波路を［０００１］と垂直な方向、すなわち［１１－２０］方向に形成すれば、遷移確率を２倍程度大きくできることがわかる（表中のエネルギ値は光学遷移の生じ易さを示し、大きいほど遷移確率は高い）。これにより、利得が増大し、発振に必要なしきい値キャリア密度が低減され、窒化ガリウム系半導体レーザを実現できる。

【００１１】

【発明の実施の形態】本発明の第一の実施例を図１を用いて説明する。

【００１２】図示のように、この多重量子井戸レーザは、（１－１００）面ｎ型ＺｎＯ基板１上に、基板１と格子整合するＩｎＧａＮバッファ層２、Ｓｉをドープしたｎ－ＩｎＧａＡｌＮ層３、アンドープ多重量子井戸からなる活性層４、Ｍｇをドープしたｐ－ＩｎＧａＡｌＮ層５が順次積層されて構成される。これらの各層はガスソース分子線成長法によりエピタキシャル成長される。バッファ層２、ｎ－ＩｎＧａＡｌＮ層３、ｐ－ＩｎＧａＡｌＮ層５の膜厚はそれぞれ、２μｍ、０．１５μｍ、０．１５μｍである。アンドープ多重量子井戸活性層４は、拡大して示したように、$In_{0.2}Ga_{0.6}Al_{0.2}N$障壁層（膜厚８ｎｍ）６と$In_{0.1}Ga_{0.9}N$井戸層（膜厚４ｎｍ）７が交互に積層形成された二重量子井戸構造を有する。ここで井戸層７の組成比は、ＺｎＯの格子定数をａとしたとき、これからの格子定数のずれΔａ／ａが－１．８％となるように設定されており、二軸性の引っ張り歪が印加されている。以上のようにして得られたウエハーの基板１の裏面にｎ側Ｉｎ電極８、ｐ型ＩｎＧａＡｌＮ層５にＡｌ電極９を蒸着したのち、（１１－２０）面でへき開し［１１－２０］方向（図１の活性層４の側面側）に長さ約８００μｍの共振器を形成し半導体レーザを作製する。本半導体レーザは室温においてしきい値電流約５０ｍＡで連続発振した。発振波長は約４２０ｎｍであった。

【００１３】本実施例において、ＺｎＯ基板の面方位を（１１－２０）面とし、共振器を［１－１００］方向に形成した半導体レーザを同様に作製したところ、しきい値電流、発振波長はほぼ同等のものが得られた。また、本実施例において、ＺｎＯ基板の面方位を（１－１００）面から［０００１］方向に１０度傾斜した面とし、共振器を［１１－２０］方向に形成した半導体レーザを同様に作製したところ、しきい値電流、発振波長はほぼ同等のものが得られた。

【００１４】次に本発明第二の実施例を図２を用いて説明する。

【００１５】図示のように、（１－１００）面ｎ型ＺｎＯ基板１上に成長した$In_{1-x}Ga_xN$の組成ｘが０．８から０．５まで連続的に変化するＩｎＧａＮ組成傾斜層１１上に、組成傾斜層１１に格子整合する$In_{0.5}Ga_{0.5}N$バッファ層１２、Ｓｉをドープしたｎ－ＩｎＧａＡｌＮ層１３、アンドープ多重量子井戸からなる活性層１４、Ｍｇをドープしたｐ－ＩｎＧａＡｌＮ層１５が順次積層されて構成される。これらの各層はガスソース分

子線成長法によりエピタキシャル成長される。バッファ層12、n－InGaAlN層13、p－InGaAlN層15の膜厚はそれぞれ、2μm、0．15μm、0．15μmである。アンドープ多重量子井戸活性層14は、拡大して示したように、$In_{0.35}Ga_{0.5}Al_{0.15}$N障壁層（膜厚5nm）16と$In_{0.2}Ga_{0.8}$N井戸層（膜厚3nm）17が交互に積層形成された二重量子井戸構造を有する。ここで井戸層17の組成比は、$In_{0.5}Ga_{0.5}$Nバッファ層の格子定数をaとしたとき、これからの格子定数のずれΔa／aが－2．0％となるように設定されており、二軸性の引っ張り歪が印加されている。以上のようにして得られたウエハーの基板1の裏面にn側In電極8、p型InGaAlN層5にAl電極9を蒸着したのち、（11－20）面でへき開し［11－20］方向に長さ約800μmの共振器を形成し半導体レーザを作製する。本半導体レーザは室温においてしきい値電流約60mAで連続発振した。発振波長は約450nmであった。

【0016】上記の実施例では量子井戸層としてInGaN、基板としてZnOを用いたが、本発明の発光素子に使用される構成はこれに限定されず、例えば図3～図4に示す構成とすることができる。

【0017】図3に示した半導体レーザは、n型ZnO基板1の（1－100）面上に、基板1と格子整合するInGaNバッファ層2が成長され、このバッファ層2上にn－InGaAlN層3、アンドープ単一量子井戸活性層21、p－InGaAlNクラッド層5が順次積層されて構成されている。これらの各層はガスソース分子線成長法によりエピタキシャル成長される。ここで量子井戸活性層21は、拡大して示したように、$GaN_{0.95}As_{0.05}$井戸層（膜厚5nm）22が$In_{0.2}Ga_{0.6}Al_{0.2}$N障壁層（膜厚10nm）23にはさまれた単一量子井戸構造を有する。ここで井戸層22の組成比は、ZnOの格子定数をaとしたとき、これからの格子定数のずれΔa／aが－1．8％となるように設定されており、二軸性の引っ張り歪が印加されている。以上のようにして得られたウエハーの基板1の裏面にn側In電極8、p型InGaAlN層5にAl電極9を蒸着したのち、（11－20）面でへき開し［11－20］方向に長さ約800μmの共振器を形成し半導体レーザを作製する。本半導体レーザは室温においてしきい値電流約50mAで連続発振した。発振波長は約450nmであった。

【0018】図4に示した半導体レーザは、サファイア基板31の（1－100）面上に、InGaNバッファ層2が成長され、このバッファ層2上にn－InGaAlN層3、アンドープ多重量子井戸活性層4、p－InGaAlNクラッド層5が順次積層されて構成されている。これらの各層は有機金属気相成長法によりエピタキシャル成長される。ここで量子井戸活性層4は、拡大して示したように、$In_{0.2}Ga_{0.6}Al_{0.2}$N障壁層（膜厚8nm）6と$In_{0.1}Ga_{0.9}$N井戸層（膜厚4nm）7が交互に2周期積層形成された多重量子井戸構造を有する。ここで井戸層7の組成比は、InGaNバッファ層の格子定数をaとしたとき、これからの格子定数のずれΔa／aが－1．8％となるように設定されており、二軸性の引っ張り歪が印加されている。以上のようにして得られたウエハーのp－InGaAlNクラッド層5と量子井戸活性層4の一部をエッチングにより取り除き、n－InGaAlNクラッド層3を露出させ、p－クラッド層とn－クラッド層にAl電極9を蒸着したのち、（11－20）面でへき開し［11－20］方向に長さ約800μmの共振器を形成し半導体レーザを作製する。本半導体レーザは室温においてしきい値電流約70mAで連続発振した。発振波長は約420nmであった。

【0019】なお、本発明は、実施例に示したレーザ構造に限らず、さまざまな半導体レーザ、例えば分布帰還型レーザ、ブラッグ反射型レーザ、波長可変レーザ、外部共振器付きレーザにも適用できる。

【0020】

【発明の効果】以上のように、本発明の窒化ガリウム系化合物半導体発光素子は、面方位が（1－100）面、あるいは（11－20）面である基体結晶上に二軸性の引っ張り歪をもつ量子井戸活性層を成長し、導波路を［0001］方向に垂直な方向に作製しているので、価電子帯上部の状態密度を小さく、かつ、遷移確率を増大できる。これにより、利得が増大し、しきい値電流密度を低減できるため、窒化ガリウム系化合物半導体レーザを実現できる。

【0021】

【図面の簡単な説明】

【図1】本発明実施例の半導体レーザの構成図。

【図2】本発明実施例の半導体レーザの構成図。

【図3】本発明実施例の半導体レーザの構成図。

【図4】本発明実施例の半導体レーザの構成図。

【図5】歪の無い場合のウルツ鉱型GaNの価電子帯上部のエネルギー分散を示す図。。

【図6】2％二軸性引っ張り歪を印加した場合のウルツ鉱型GaNの価電子帯上部のエネルギー分散を示す図。

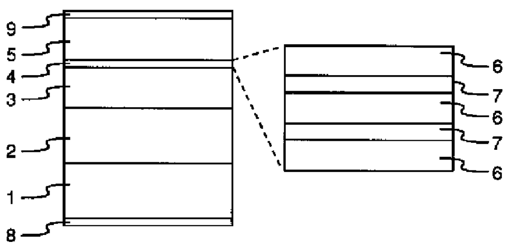
【符号の説明】

1…（1－100）面n型ZnO基板、2…InGaNバッファ層、3…n－InGaAlN層、4…アンドープ多重量子井戸活性層、5…p－InGaAlN層、6…$In_{0.2}Ga_{0.6}Al_{0.2}$N障壁層、7…$In_{0.1}Ga_{0.9}$N井戸層、8…In電極、9…Al電極、11…InGaN組成傾斜層、12…$In_{0.5}Ga_{0.5}$Nバッファ層、13…n－InGaAlN層、14…アンドープ多重量子井戸活性層、15…p－InGaAlN層、16…$In_{0.35}Ga_{0.5}Al_{0.15}$N障壁層、17…$In_{0.2}$G

$a_{0.8}N$井戸層、２１…アンドープ単一量子井戸活性層、２２…$GaN_{0.95}As_{0.05}$井戸層、２３…$In_{0.2}$＊＊$Ga_{0.6}Al_{0.2}N$障壁層、３１…サファイア基板。

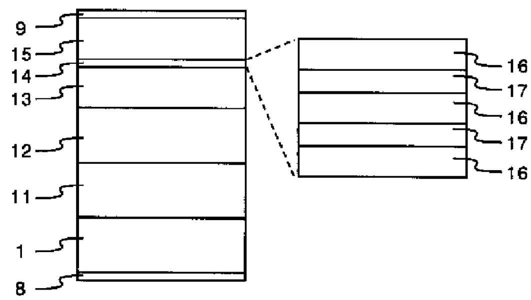
【図１】

図1



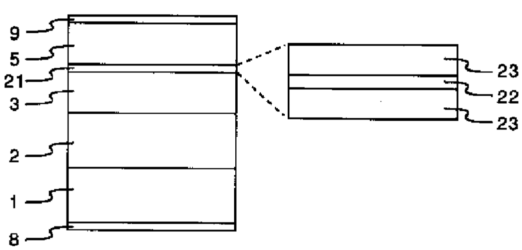
【図２】

図2



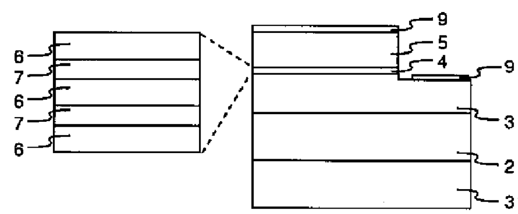
【図３】

図3



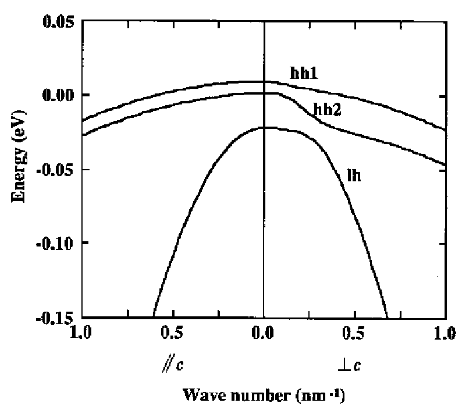
【図４】

図4



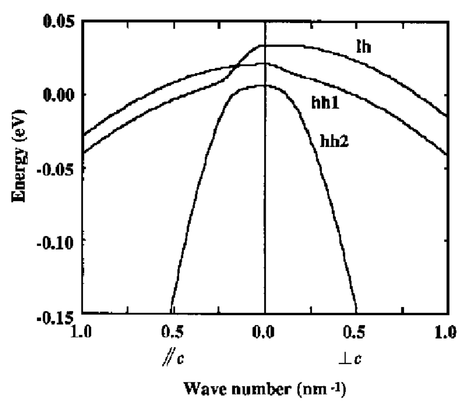
【図５】

図5



【図６】

図6



フロントページの続き

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Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

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The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

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III. <u>CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION</u>

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract is provided (as a partial translation) for the following reference(s): JP-9-116225-A.

A machine generated translation is provided for the following reference(s): JP-9-116225-A.

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A copy of the Office Action, dated January 9, 2012, for copending U.S. Application No. 12/947,470 is provided. US-6,600,175-B1, cited in said Office Action, was previously cited in the Information Disclosure Statement filed March 16, 2011. US-3,875,456-A and US-5,847,507-A, also cited in said Office Action, were previously cited in the Information Disclosure Statement filed January 14, 2009.

A copy of the Office Action, dated January 30, 2012, for copending U.S. Application No. 12/942,792 is provided. US-5,847,507-A, cited in said Office Action, was previously cited in the Information Disclosure Statement filed January 14, 2009.

A copy of the Office Action, dated March 13, 2012, for copending U.S. Application No. 13/210,027 is provided. US-5,847,507-A, cited in said Office Action, was previously cited in the Information Disclosure Statement filed January 14, 2009.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

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☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VI. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: APR 5 2012

Respectfully submitted,

Reg. No.

By Corina Tanasa 64042

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703-205-8000

Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☑ Other: **Three (3) U.S. Office Actions**

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete If Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner Initial *	Cite No.	Document Number Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-3,560,649	02-02-1971	Anderson	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

Examiner Signature		Date Considered	

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PTO/SB/08b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	2	U.S. Office Action issued in co-pending U.S. application no. 12/689,681 on May 10, 2012.	

Examiner Signature		Date Considered	

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Electronic Acknowledgement Receipt

EFS ID:	13315360
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/Patti Young
Filer Authorized By:	Corina E. Tanasa
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	23-JUL-2012
Filing Date:	14-SEP-2009
Time Stamp:	15:46:30
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20120723IDS.pdf	3610061 89d52ad0b5ea95ed756a0d4d8883473e827deb2c	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	6
	Information Disclosure Statement (IDS) Form (SB08)	7	8

Warnings:

Information:

2	Non Patent Literature	20120510NonfinalRejection.pdf	483853 e217f267002443e0a31af9c851620f4a54329d78	no	11

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Information:

Total Files Size (in bytes):	4093914

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Yoshinori SHIMIZU et al.

Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

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U.S. Application No. and U.S. Filing Date
12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☐ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A U.S. Office Action (submitted herein) issued in co-pending U.S. application No. 12/689,681 on May 10, 2012 cited US 3,560,649 submitted herein.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than

three months prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: July 23, 2012 Respectfully submitted,

By Corina Tanasa Reg. No. 64042

for D. Richard Anderson
Registration No.: 40,439 CORINA TANASA

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703-205-8000

Attachment(s):
- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☐ Other:

PTO/SB/08a (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number: Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-5,247,533	09-21-1993	Okazaki et al.	
	2	US-5,408,120	04-18-1995	Manabe et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	3	JP 7-335942	12-22-1995	Nichia Chem Ind Ltd.		✔

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	4	Singaporean Examination and Search Report issued on July 2, 2012 in counterpart Singapore Patent Application No. 201007151-2.	✔
	5	Singaporean Examination and Search Report issued on July 5, 2012 in counterpart Singapore Patent Application No. 201007150-4.	✔

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

et

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-335942
(43)Date of publication of application : 22.12.1995

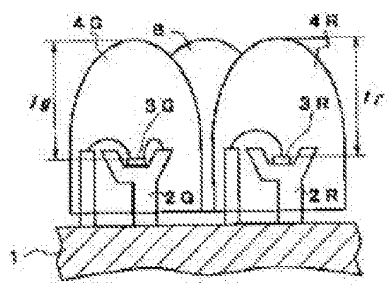
(51)Int.Cl. H01L 33/00
G09F 9/33

(21)Application number : 06-131531
(22)Date of filing : 14.06.1994

(71)Applicant : NICHIA CHEM IND LTD
(72)Inventor : NAGAI YOSHIFUMI

(54) FULL-COLOR LED DISPLAY

(57)Abstract:
PURPOSE: To obtain the stable white balance with high luminance and small power consumption by a method wherein a green color LED and a blue color LED which have respective light emitting chips made of gallium nitride system compound semiconductor are combined together.
CONSTITUTION: Respective lead frames of a red color LED, a green color LED and a blue color LED (B) are electrically connected to the surface of a board 1 on which wiring patterns are formed. The green color LED has a green light emitting chip 3G which is composed of a sapphire substrate and a gallium nitride system compound semiconductor layer built up on the sapphire substrate and whose dimensions are 100 μm thick and 350 μm square. The green light emitting chip has a double-hetero structure composed of an InGaN active layer and a GaAlN cladding layer. The blue color LED (B) has a blue light emitting chip whose dimensions, etc., are the same as those of the green light emitting chip 3G except that the composition of the InGaN active layer is different. Further, in order to adjust directional characteristics, the substrate of the red light emitting chip 3R of the red color LED is polished.



CLAIMS

[Claim(s)]
[Claim 1]A full color LED display comprising:
A red LED lamp which constitutes stroke matter.
A green LED lamp.
A light emitting chip in which said green LED lamp and a blue LED lamp consist of a gallium nitride system compound semiconductor in a full color LED display which a blue LED lamp is connected on the same board, and changes.

[Claim 2]A full color LED display given in Claim 1 in which a half angle of the directional characteristics of the aforementioned red LED lamp is characterized by being the same as that of a half angle of the directional characteristics of a green LED lamp and a blue LED lamp.
[Claim 3]With resin or glass, the mold of the aforementioned red LED lamp, a green LED lamp, and the blue LED lamp is carried out to the shape of a lens, they change, and a light emitting chip The peak of a mold lens of the aforementioned red LED lamp, Distance with the surface of a light emitting chip which it had in the red LED lamp The peak of a mold lens of said green LED lamp and a blue LED lamp, A full color LED display given in Claim 2, wherein it is adjusted so that it may become substantially equal to distance with the surface of a light emitting chip which it had in the green LED lamp and a blue LED lamp, and a half angle of the directional characteristics of a red LED lamp is adjusted.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]The LED lamp to which the mold of the light emitting chip was carried out with resin, glass, etc. as for the present invention. Red LED, green LED, and blue LED which constitute stroke matter especially are related with the full color LED display which is connected on the same board and changes about the LED display which connects on the same board it (is hereafter called LED). [two or more]
[0002]
[Description of the Prior Art]That with which the light emitting chip installed on the leadframe was able to compare regularly LED sealed by lens shape with resin, glass, etc. on the substrate is known by the LED display. Although the thing of the multicolor which used red LED and green LED is already put in practical use by the present LED display, the full color display has not yet resulted in utilization in a trial production stage.
[0003]As for the full color LED display made as an experiment now, SiC is used for red LED as a material of a light emitting chip at GaP and blue LED at GaAlAs, GaAsP, and green LED. However, compared with the luminous intensity of red LED, the luminous intensity of green LED and blue LED was low, and since blue LED in particular had 1/100 or less, there was a fault that a high-intensity display was not obtained.
[0004]The aforementioned display has increased the number of green LED and blue LED to the number of red LED in stroke matter in order to compensate this fault, but when the number of LED in stroke matter increases, the resolution of the whole display worsens and, moreover, there is a fault that power consumption is large. Since the directional characteristics of each LED differed when the light ratio of LED of each luminescent color and what is called a white balance are using LED which consists of three kinds of light emitting chips when displaying white further again, there was a fault of not being fixed.
[0005]
[Problem to be solved by the invention]Accomplish the present invention in order to solve the above-mentioned fault, and the place made into the purpose uses LED with high luminous intensity, and realize little display of power consumption with high-intensity, and. It is in realizing the full color LED display in which the white balance stable by combining LED which can furthermore adjust directional characteristics easily is obtained.
[0006]
[Means for solving problem]In order to improve the luminosity of a full color LED display, it is necessary to use high green LED and blue LED of luminous intensity first. Directional characteristics need to arrange in in order to obtain the stable white balance a few LED which corresponded as much as possible to stroke matter. We newly find out the blue LED and green LED which can satisfy the demand simultaneously, and came to solve the above-mentioned problem. Namely, the full color LED display of the present invention, In the full color LED display in which it is connected on the same substrate and red LED which constitutes stroke matter, green LED, and blue LED change, above-mentioned green LED and blue LED are provided with the light emitting chip which consists of a gallium nitride system compound semiconductor.

[0007]The 2nd of the present invention is characterized by the half angle of the directional characteristics of red LED being the same as the half angle of the directional characteristics of green LED and blue LED. That is, since it is blue LED and a green LED identical material, the directional characteristics of the conventional red LED are adjusted to green and blue LED.
[0008]With resin or glass, the mold of the 3rd of the present invention is carried out to the shape of a lens, it changes, and a light emitting chip red LED, green LED, and blue LED The peak of the mold lens of the aforementioned red LED lamp, Distance with the surface of the light emitting chip which it had in the red LED lamp The peak of the mold lens of the above-mentioned green LED lamp and a blue LED lamp, It is adjusted so that it may become substantially equal to distance with the surface of the light emitting chip which it had in the green LED lamp and a blue LED lamp, and the half angle of the directional characteristics of a red LED lamp is adjusted. It cannot be overemphasized that green LED and blue LED are provided with the light emitting chip which consists of a gallium nitride system compound semiconductor.
[0009]In red LED used in the LED display of the present invention, LED provided with the material of the conventional light emitting chip can be used, these LED has the degree of luminescent light of 1 cds or more, and, as for the radiant power output, GaAlAs, GaAsP, etc. have 1 mW or more.
[0010]Next, these are provided with the light emitting chip which consists of a gallium nitride system compound semiconductor ($In_XAl_YGa_{1-X-Y}N$, $0<=X$, $0<=Y$, $X+Y<=1$) as mentioned above although it is green LED and blue LED which are the characteristics of the present invention. As for the light emitting chip, it is preferable that it is terrorism structure in the double which makes InGaN an active layer and makes GaN or GaAlN a cladding layer. Because, the light emitting chip which makes InGaN an active layer can change the luminescent color even to a green region from the region of the wavelength of 380 nm - 580 nm, and purple-blue by making composition ratio (In/Ga) to Ga of In or less into 0.4. Since a gallium nitride system compound semiconductor is a transited [directly] type semiconductor, when it considers it as a light emitting chip, it can realize LED with high luminous intensity. That in which both have 1 cds or more is specifically used for the degree of luminescent light of green LED used for the LED display of the present invention, and blue LED, and, as for optical power, it is preferable to use a thing of 0.5 mW or more.
[0011]As for the half angle of red, green, and blue LED, it is preferable to adjust to the range of **20 degrees - **70 degrees to the center of a LED lens. It is because luminosity will become low if larger [if smaller than 20 degrees, the directivity of a display will become strong and a white balance will not be stabilized easily, and] than 70 degrees.
[0012]Although there are various methods in adjusting the half angle of each LED, when green LED and blue LED are used as the light emitting chip which consists of a gallium nitride system compound semiconductor, the height of the surface of a red LED chip is equalized with the height of a gallium nitride system compound semiconductor light emitting chip, and a half angle is adjusted. Because, the thickness of a gallium nitride system compound semiconductor light emitting chip is only 150 micrometers or less, and the GaAlAs which is a light emitting chip of red LED is not less than 300 micrometers in the thickness to it. The directional characteristics of three kinds of LED can be doubled by using in many cases what has the same shape of lead frame and lens shape for LED used on a display, and doubling the height of the surface of the chip of red LED with green and blue LED, if these are the same. This is a characteristic effect at the time of the thickness of a light emitting chip using a gallium nitride system compound semiconductor light emitting chip of 150 micrometers or less for green LED and blue LED, and using the light emitting chip consisting of material which is different from a gallium nitride system compound semiconductor in a top thicker than 150 micrometers for red LED.
[0013]
[Function]By using as the identical material the light emitting chip which constitutes green LED and blue LED, the LED display of the present invention can do lens shape of the resin etc. which seal the size of a light emitting chip, the form of the leadframe which places a light

emitting chip, a light emitting chip, and a leadframe as it is the same. Since this green and blue LED are the same, the half angle of a mold lens is also the same, and when a display is constituted, it can do that it is easy to stabilize a white balance.

[0014]A gallium nitride system compound semiconductor is also a transited [directly] type semiconductor, and, as for LED using this, the luminous intensity of 1 cds or more and 0.5 mW or more of optical power have both. therefore, by using such LED as a green component and a blue component, rather than the display constituted from a conventional material, the number of LED is lessened, and is boiled markedly, and what has high luminosity can be realized.

[0015]What is necessary is to adjust only red LED for adjusting the half angle of a mold lens, since green LED and blue LED are the same. A half angle can be adjusted by equalizing the distance of the surface of the light emitting chip which is in red LED for that purpose, and the peak of a mold lens with green LED and blue LED. Thereby, all of the half angle of 3 colors will gather, and it becomes possible to obtain the stable white balance.

[0016]

[Working example]Fig.1 is a plan view showing one working example of the full color LED display of an application concerned. this shows the display screen -- red LED (R), green LED (G), and blue LED (B) -- one piece is arranged in the shape of [each] delta, and forms stroke matter, respectively. Fig.2 is a schematic cross section showing the structure of the stroke matter of the display of Fig.1, and the leadframe 2 of red LED (R), and green LED (G) and blue LED (B) is electrically connected to the surface of the substrate 1 by which pattern wiring was carried out, respectively.The leadframe in particular of blue LED is not illustrating.

[0017]Red LED (R) has the red light chip 3R of 100 micrometers in thickness, and a 350-micrometer angle which laminated GaAlAs on a GaAs substrate.

The mold of the leadframe 2R on which the light emitting chip 3R was placed is carried out to the shape of a lens with a transparent epoxy resin, and it forms the mold lens 4.

By grinding a GaAs substrate, the thickness of the red light chip 3R is adjusted so that it may become the same as that of the thickness of a green emission chip and a blue light chip. As for the mold lens 4, the mold of the half angle of the directional characteristics is carried out using B, G, and a mold that will R all be **30 degrees from a lens center. The luminous intensity of this red LED (R) has 2 cds and a luminous wavelength of 640 nm in 10 mA and 2V.

[0018]Next, green LED (G) has the green emission chip 3G of 100 micrometers in thickness, and a 350-micrometer angle which laminated a gallium nitride system compound semiconductor on silicon on sapphire.

A green emission chip makes InGaN an active layer, and let it be terrorism structure to double which makes GaAlN a cladding layer.

This green emission chip 3G is also placed on the leadframe 2R and the leadframe 2G of identical shape, and the mold is carried out with the same lens shape as red LED (R) with the same transparent epoxy resin 4. The luminous intensity of this green LED (G) has 4 cds and a luminous wavelength of 420 nm in 20 mA and 3.6V.

[0019]Next, blue LED (B) only differs in composition of InGaN of the green emission chip 3G and an active layer, it is the same in thickness and all sizes, and the luminous intensity of blue LED has 1 cd and a luminous wavelength of 360 nm in 20 mA and 3.6V.

[0020]By grinding the substrate of the red light chip 3R of the aforementioned red LED (R), in order to adjust directional characteristics, Distance (lr) from the surface of the chip to the peak of the mold lens 4R is made substantially equal to the distance (lg) from the surface of the green emission chip 3G of above-mentioned green LED (G) to the peak of the mold lens 4G. It cannot be overemphasized that green LED (G) and blue LED (B) are the same.

[0021]The plan view showing the form of the red light chip 3R seen from the mold lens 4R side and the plan view showing the form of the green emission chip 3G similarly seen from the mold lens 4G side are compared and shown in Fig.3. The slash part of Fig.3 shows the light-emitting part of the light emitting chip. It cannot be overemphasized that the form of the green emission chip 3G and the blue light chip 3B is the same. As mentioned above, since the green emission chip 3G is using sapphire as the substrate, as shown in this figure, positive and negative two

electrodes are formed from the same surface side. The chip central part is made to emit light by arranging the position of the ball at the time of furthermore carrying out the wire bond of the two electrodes on a diagonal line. On the other hand, it arranges the ball on a corner by the present invention that a ball of a red light chip is usually provided by central part of the rectangular chip.
Therefore, a light-emitting part of the red light chip 3R is carried out in the center.
Thus, it becomes possible by doubling the position of the light-emitting part of the red light chip 3R with the green emission chip 3G and the blue light chip 3B to improve the directivity of a LED display further.
[0022]In delta arrangement, LED of R, G, and B every one piece each as mentioned above the pixel carried out, When the full color LED display of the present invention was obtained by arranging the length 480 and width every 640, the luminosity was tens times bright compared with what uses the conventional green LED and blue LED, and usable enough outdoors. Furthermore, the white balance was adjusted very well and this display had the white of the same color tone in the angle of **30 degrees from the display transverse plane.
[0023]
[Effect of the Invention]according to [as described above] the present invention -- red LED, green LED, and each blue LED -- since realization of a full color display is attained by every [a piece], stroke matter can be made small compared with the conventional display, and resolution is markedly alike and improves. Also in directional characteristics, since green LED and blue LED are identical materials, what is necessary is to adjust only red LED, when 3 colors is put in order on a display, and maintenance is also dramatically easy.
[0024]Further again the chip size of the light emitting chip of the conventional red LED as a secondary effect, Usually, by below a 200-micrometer angle making the red light chip size into the 350-micrometer angle of the same size as a green emission chip and a blue light chip by the present invention to very small one, Directional characteristics can be made further easy to double, and the life of the red LED itself becomes good and the reliability of a display improves.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The plan view showing one working example of the full color LED display of the present invention.
[Drawing 2]The schematic cross section showing the structure of the stroke matter of the display of Fig.1.
[Drawing 3]The plan view comparing and showing the form of the red light chip 3R seen from the mold lens side, and the form of the green emission chip 3G.
[Explanations of letters or numerals]
1 .... Substrate
2 .... Leadframe
3 .... Light emitting chip
4 .... Mold lens

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平7－335942

(43)公開日　平成７年(1995)12月22日

(51)Int.Cl.[6]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　33/00	Ｎ			
Ｇ０９Ｆ　9/33		0834－5H		

審査請求　未請求　請求項の数３　ＯＬ　（全 ４ 頁）

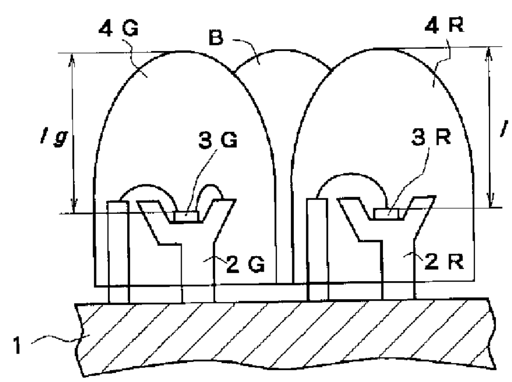
(21)出願番号	特願平6－131531	(71)出願人	000226057 日亜化学工業株式会社 徳島県阿南市上中町岡491番地100
(22)出願日	平成６年(1994)６月14日	(72)発明者	永井　芳文 徳島県阿南市上中町岡491番地100　日亜化学工業株式会社内

(54)【発明の名称】　フルカラーＬＥＤディスプレイ

(57)【要約】

【目的】　光度の高いＬＥＤを使用して、高輝度で消費電力の少ないディスプレイを実現すると共に、さらに指向特性を容易に調整できるＬＥＤを組み合わせることにより安定したホワイトバランスが得られるフルカラーＬＥＤディスプレイを実現する。

【構成】　フルカラーＬＥＤディスプレイで、緑色ＬＥＤランプ（Ｇ）および青色ＬＥＤランプ（Ｂ）は窒化ガリウム系化合物半導体よりなる発光チップを備えており、赤色ＬＥＤランプ（Ｒ）の指向特性の半値角が、緑色ＬＥＤランプおよび青色ＬＥＤランプの指向特性の半値角と同一となるように調整されている。



【特許請求の範囲】

【請求項1】　一画素を構成する赤色ＬＥＤランプと、緑色ＬＥＤランプと、青色ＬＥＤランプとが、同一基板上に接続されて成るフルカラーＬＥＤディスプレイにおいて、前記緑色ＬＥＤランプおよび青色ＬＥＤランプは窒化ガリウム系化合物半導体よりなる発光チップを備えることを特徴とするフルカラーＬＥＤディスプレイ。

【請求項2】　前記赤色ＬＥＤランプの指向特性の半値角が、緑色ＬＥＤランプおよび青色ＬＥＤランプの指向特性の半値角と同一であることを特徴とする請求項１記載のフルカラーＬＥＤディスプレイ。

【請求項3】　前記赤色ＬＥＤランプ、緑色ＬＥＤランプ、および青色ＬＥＤランプは発光チップが樹脂またはガラスでレンズ状にモールドされて成り、前記赤色ＬＥＤランプのモールドレンズの頂点と、その赤色ＬＥＤランプ内に備えられた発光チップの表面との距離が、前記緑色ＬＥＤランプおよび青色ＬＥＤランプのモールドレンズの頂点と、その緑色ＬＥＤランプおよび青色ＬＥＤランプ内に備えられた発光チップの表面との距離にほぼ等しくなるように調整されて、赤色ＬＥＤランプの指向特性の半値角が調整されていることを特徴とする請求項２に記載のフルカラーＬＥＤディスプレイ。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、発光チップが樹脂、ガラス等でモールドされたＬＥＤランプ（以下、ＬＥＤという）を同一基板上に複数接続して成るＬＥＤディスプレイに関し、特に、一画素を構成する赤色ＬＥＤと緑色ＬＥＤと青色ＬＥＤとが同一基板上に接続されて成るフルカラーＬＥＤディスプレイに関する。

【０００２】

【従来の技術】ＬＥＤディスプレイには、リードフレーム上に設置された発光チップが樹脂、ガラス等で例えばレンズ形状に封止されたＬＥＤを、基板上に規則的に並べられたものが知られている。現在ＬＥＤディスプレイには、赤色ＬＥＤと緑色ＬＥＤを用いたマルチカラーのものがすでに実用化されているが、フルカラーディスプレイは未だ試作段階で実用化には至っていない。

【０００３】現在試作されているフルカラーＬＥＤディスプレイは、発光チップの材料として、赤色ＬＥＤにＧａＡｌＡｓ、ＧａＡｓＰ、緑色ＬＥＤにＧａＰ、青色ＬＥＤにＳｉＣが用いられている。しかし、赤色ＬＥＤの光度に比べて、緑色ＬＥＤおよび青色ＬＥＤの光度が低く、特に青色ＬＥＤは１／１００以下しかないため、高輝度のディスプレイが得られないという欠点があった。

【０００４】この欠点を補う目的で、前記ディスプレイは一画素中の赤色ＬＥＤの数に対して、緑色ＬＥＤ、青色ＬＥＤの数を増やしているが、一画素中のＬＥＤの数が増えると、ディスプレイ全体の解像度が悪くなり、しかも消費電力が大きいという欠点がある。さらにまた白色を表示する際、各発光色のＬＥＤの光度比、いわゆるホワイトバランスが、３種類の発光チップからなるＬＥＤを使用していることにより、各ＬＥＤの指向特性が異なるため、一定しないという欠点があった。

【０００５】

【発明が解決しようとする課題】本発明は上記欠点を解決するために成されたものであって、その目的とするところは光度の高いＬＥＤを使用して、高輝度で消費電力の少ないディスプレイを実現すると共に、さらに指向特性を容易に調整できるＬＥＤを組み合わせることにより安定したホワイトバランスが得られるフルカラーＬＥＤディスプレイを実現することにある。

【０００６】

【課題を解決するための手段】フルカラーＬＥＤディスプレイの輝度を向上させるには、まず光度の高い緑色ＬＥＤと青色ＬＥＤを用いる必要がある。さらに、安定したホワイトバランスを得るためには指向特性ができるだけ一致したＬＥＤを一画素に数少なく並べる必要がある。我々はその要求を同時に満足できる青色ＬＥＤと緑色ＬＥＤとを新たに見いだし、上記問題を解決するに至った。即ち本発明のフルカラーＬＥＤディスプレイは、一画素を構成する赤色ＬＥＤと、緑色ＬＥＤと、青色ＬＥＤとが、同一基板上に接続されて成るフルカラーＬＥＤディスプレイにおいて、前記緑色ＬＥＤおよび青色ＬＥＤは窒化ガリウム系化合物半導体よりなる発光チップを備えることを特徴とする。

【０００７】さらに、本発明の第２は、赤色ＬＥＤの指向特性の半値角が、緑色ＬＥＤおよび青色ＬＥＤの指向特性の半値角と同一であることを特徴とする。つまり、青色ＬＥＤと緑色ＬＥＤ同一材料であるので、従来の赤色ＬＥＤの指向特性を緑、および青色ＬＥＤに調整する。

【０００８】また本発明の第３は、赤色ＬＥＤ、緑色ＬＥＤ、および青色ＬＥＤは発光チップが樹脂またはガラスでレンズ状にモールドされて成り、前記赤色ＬＥＤランプのモールドレンズの頂点と、その赤色ＬＥＤランプ内に備えられた発光チップの表面との距離が、前記緑色ＬＥＤランプおよび青色ＬＥＤランプのモールドレンズの頂点と、その緑色ＬＥＤランプおよび青色ＬＥＤランプ内に備えられた発光チップの表面との距離にほぼ等しくなるように調整されて、赤色ＬＥＤランプの指向特性の半値角が調整されていることを特徴とする。なお緑色ＬＥＤと青色ＬＥＤとは窒化ガリウム系化合物半導体よりなる発光チップを備えていることはいうまでもない。

【０００９】本発明のＬＥＤディスプレイにおいて使用する赤色ＬＥＤには、ＧａＡｌＡｓ、ＧａＡｓＰ等、従来の発光チップの材料を備えるＬＥＤを使用でき、それらＬＥＤは発光光度１ｃｄ以上、発光出力は１ｍW以上を有している。

【００１０】次に本発明の特徴である緑色ＬＥＤおよび

青色ＬＥＤであるが、これらは前記のように窒化ガリウム系化合物半導体（$In_XAl_YGa_{1-X-Y}N$、$0 \leqq X$、$0 \leqq Y$、$X+Y \leqq 1$）よりなる発光チップを備えている。その発光チップは、ＩｎＧａＮを活性層にし、ＧａＮまたはＧａＡｌＮをクラッド層とするダブルヘテロ構造であることが好ましい。なぜなら、ＩｎＧａＮを活性層とする発光チップは、ＩｎのＧａに対する組成比（Ｉｎ／Ｇａ）を０．４以下とすることにより、波長３８０ｎｍ～５８０ｎｍと青紫の領域から緑色の領域にまで発光色を変化させることができる。また、窒化ガリウム系化合物半導体は直接遷移型の半導体であるため、発光チップとした際に光度の高いＬＥＤを実現できる。具体的には、本発明のＬＥＤディスプレイに使用する緑色ＬＥＤ、および青色ＬＥＤの発光光度は、両者とも１ｃｄ以上を有するものを使用し、光出力は０．５mW以上のものを使用することが好ましい。

【００１１】また赤色、緑色、青色ＬＥＤの半値角はＬＥＤレンズの中心に対し±２０°～±７０°の範囲に調整することが好ましい。２０°より小さいとディスプレイの指向性が強くなりホワイトバランスが安定しにくく、７０°よりも大きいと輝度が低くなるからである。

【００１２】各ＬＥＤの半値角を調整するには種々の方法があるが、緑色ＬＥＤ、および青色ＬＥＤを窒化ガリウム系化合物半導体よりなる発光チップとした際、赤色ＬＥＤチップの表面の高さを窒化ガリウム系化合物半導体発光チップの高さと同一にして半値角を調整する。なぜなら、窒化ガリウム系化合物半導体発光チップの厚さは１５０μｍ以下しかなく、それに対し、赤色ＬＥＤの発光チップであるＧａＡｌＡｓ等はその厚さが３００μｍ以上ある。ディスプレイで使用されるＬＥＤにはリードフレーム形状、レンズ形状が同一のものが使用されることが多く、これらが同一であれば、赤色ＬＥＤのチップの表面の高さを、緑色、青色ＬＥＤに合わせてやることにより、３種類のＬＥＤの指向特性を合わせることができる。これは発光チップの厚さが１５０μｍ以下の窒化ガリウム系化合物半導体発光チップを緑色ＬＥＤおよび青色ＬＥＤに使用し、１５０μｍより厚い上に窒化ガリウム系化合物半導体と異なる材料よりなる発光チップを赤色ＬＥＤに使用した際の特有の効果である。

【００１３】

【作用】本発明のＬＥＤディスプレイは、緑色ＬＥＤ、青色ＬＥＤを構成する発光チップを同一材料としていることにより、発光チップの大きさ、発光チップを載置するリードフレームの形状、発光チップおよびリードフレームを封止する樹脂等のレンズ形状を同一とできる。この緑色と青色のＬＥＤが同一であるから、モールドレンズの半値角も同一であり、ディスプレイを構成した際にホワイトバランスを安定させやすくできる。

【００１４】また窒化ガリウム系化合物半導体は直接遷移型の半導体でもあり、これを用いたＬＥＤは両者とも

光度１ｃｄ以上、光出力０．５mW以上ある。従ってこれらのＬＥＤを緑色成分、および青色成分として用いることにより、従来の材料で構成したディスプレイよりも、ＬＥＤの数を少なくして格段に輝度の高いものを実現できる。

【００１５】さらに、緑色ＬＥＤおよび青色ＬＥＤが同一であるので、モールドレンズの半値角を調整するには赤色ＬＥＤのみを調整してやればよい。そのためには赤色ＬＥＤにある発光チップの表面と、モールドレンズの頂点との距離を緑色ＬＥＤ、および青色ＬＥＤと同一にすることによって半値角を調整できる。これにより、三色の半値角が全て揃うことになり、安定したホワイトバランスを得ることが可能となる。

【００１６】

【実施例】図１は本願のフルカラーＬＥＤディスプレイの一実施例を示す平面図である。これはディスプレイ画面を示しており、赤色ＬＥＤ（Ｒ）、緑色ＬＥＤ（Ｇ）、青色ＬＥＤ（Ｂ）それぞれ１個づつがΔ状に配列されて一画素を形成している。また図２は図１のディスプレイの一画素の構造を示す模式断面図であり、パターン配線された基板１の表面に、赤色ＬＥＤ（Ｒ）と、緑色ＬＥＤ（Ｇ）と、青色ＬＥＤ（Ｂ）のリードフレーム２がそれぞれ電気的に接続されている。なお、青色ＬＥＤのリードフレームは特に図示していない。

【００１７】赤色ＬＥＤ（Ｒ）は、ＧａＡｓ基板の上にＧａＡｌＡｓを積層した厚さ１００μｍ、３５０μｍ角の赤色発光チップ３Ｒを有しており、その発光チップ３Ｒが載置されたリードフレーム２Ｒは透明なエポキシ樹脂でレンズ状にモールドされてモールドレンズ４を形成している。なお赤色発光チップ３Ｒの厚さはＧａＡｓ基板を研磨することにより、緑色発光チップ、および青色発光チップの厚さと同一になるように調整してある。またモールドレンズ４は、その指向特性の半値角がＢ、Ｇ、Ｒ全てレンズ中心から±３０°になるような型を用いてモールドされている。この赤色ＬＥＤ（Ｒ）の光度は１０ｍＡ、２Ｖにおいて２ｃｄ、発光波長６４０ｎｍを有している。

【００１８】次に緑色ＬＥＤ（Ｇ）は、サファイア基板の上に窒化ガリウム系化合物半導体を積層した厚さ１００μｍ、３５０μｍ角の緑色発光チップ３Ｇを有しており、緑色発光チップはＩｎＧａＮを活性層とし、ＧａＡｌＮをクラッド層とするダブルヘテロ構造とされている。この緑色発光チップ３Ｇもリードフレーム２Ｒと同一形状のリードフレーム２Ｇ上に載置され、同じく透明なエポキシ樹脂４で赤色ＬＥＤ（Ｒ）と同一のレンズ形状でモールドされている。この緑色ＬＥＤ（Ｇ）の光度は２０ｍＡ、３．６Ｖにおいて４ｃｄ、発光波長４２０ｎｍを有している。

【００１９】次に青色ＬＥＤ（Ｂ）は、緑色発光チップ３Ｇと活性層のＩｎＧａＮの組成が異なるだけで、厚

さ、サイズ全て同一であり、青色ＬＥＤの光度は２０ｍＡ、３．６Ｖにおいて１ｃｄ、発光波長３６０ｎｍを有している。

【００２０】さらに、指向特性を調整するために、前記赤色ＬＥＤ（Ｒ）の赤色発光チップ３Ｒの基板を研磨することにより、そのチップの表面から、モールドレンズ４Ｒの頂点迄の距離（ｌｒ）を、前記緑色ＬＥＤ（Ｇ）の緑色発光チップ３Ｇの表面から、モールドレンズ４Ｇの頂点迄の距離（ｌｇ）とほぼ等しくしている。なお、緑色ＬＥＤ（Ｇ）と青色ＬＥＤ（Ｂ）とは同一であることはいうまでもない。

【００２１】さらに、図３にモールドレンズ４Ｒ側から見た赤色発光チップ３Ｒの形状を示す平面図と、同じくモールドレンズ４Ｇ側から見た緑色発光チップ３Ｇの形状を示す平面図を比較して示す。図３の斜線部は発光チップの発光部を示している。なお緑色発光チップ３Ｇと青色発光チップ３Ｂの形状は同一であることはいうまでもない。前記のように緑色発光チップ３Ｇはサファイアを基板としているため、この図に示すように同一面側から正、負の両電極が形成される。さらに両電極をワイヤーボンドする際のボールの位置を対角線上に配置することにより、チップ中央部を発光させている。一方赤色発光チップのボールは通常は矩形チップの中央部に設けられるのが、本発明においては隅部にそのボールを配することにより、赤色発光チップ３Ｒの発光部を中央にしている。このように、赤色発光チップ３Ｒの発光部の位置を緑色発光チップ３Ｇ、青色発光チップ３Ｂと合わせることにより、さらにＬＥＤディスプレイの指向性を高めることが可能となる。

【００２２】以上のようにして、Ｒ、Ｇ、ＢのＬＥＤが各一個づつΔ配列された画素を、縦４８０、横６４０づつ並べることにより本発明のフルカラーＬＥＤディスプレイを得たところ、明るさは従来の緑色ＬＥＤ、および青色ＬＥＤを使用したものに比べて数十倍も明るく、十分屋外で使用可能であった。さらにこのディスプレイはホワイトバランスが非常に良く調整され、ディスプレイ正面から±３０゜の角度内において、同じ色調の白色を有していた。

【００２３】

【発明の効果】以上説明したように本発明によると、赤色ＬＥＤ、緑色ＬＥＤ、青色ＬＥＤそれぞれ一個づつでフルカラーディスプレイが実現可能となるので、一画素を従来のディスプレイに比べて小さくでき、解像度が格段に向上する。また指向特性においても、緑色ＬＥＤと青色ＬＥＤとが同一材料であるので、ディスプレイで３色並べたときに赤色ＬＥＤのみを調整すれば良く、非常にメインテナンスも楽である。

【００２４】さらにまた、副次的な効果として、従来の赤色ＬＥＤの発光チップのチップサイズは、通常２００μｍ角以下と非常に小さいのに対し、本発明では赤色発光チップの大きさを、緑色発光チップおよび青色発光チップと同じ大きさの３５０μｍ角としていることにより、指向特性をさらに合わせやすくできると共に、赤色ＬＥＤ自体の寿命が良くなり、ディスプレイの信頼性が向上する。

【図面の簡単な説明】

【図１】　本発明のフルカラーＬＥＤディスプレイの一実施例を示す平面図。

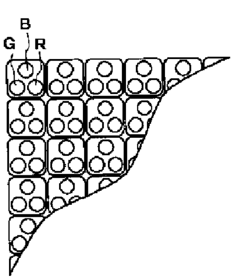
【図２】　図１のディスプレイの一画素の構造を示す模式断面図。

【図３】　モールドレンズ側から見た赤色発光チップ３Ｒの形状と、緑色発光チップ３Ｇの形状を比較して示す平面図。

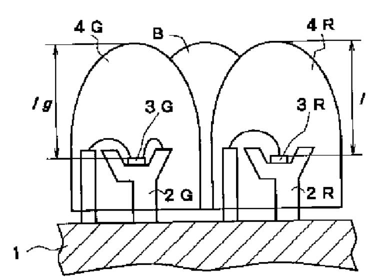
【符号の説明】

１・・・・基板
２・・・・リードフレーム
３・・・・発光チップ
４・・・・モールドレンズ

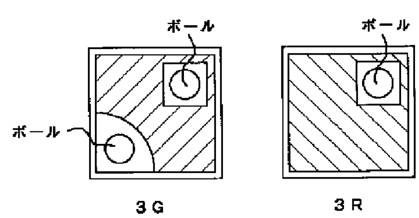
【図１】



【図２】



【図３】



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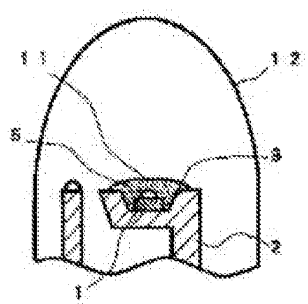
(54) LIGHT EMITTING DIODE

(57)Abstract:
PURPOSE: To provide a LED capable of avoiding color mixture even if the LEDs in different wavelength are closely arranged when a fluorescent pigment is used while the focussing of converted and emitted light is enhanced for increasing the brightness of the LED when a wavelength conversion material is contained in a resin of LED for wavelength conversion of light emitting chip.
CONSTITUTION: A sealing resin of LED comprises the first resin 11 filling up the inside of a cup 3 and the second resin 12 encircling the first resin 11 while the first resin 11 contains the fluorescent material converting the light emitting wavelength of a light emitting chip to the other wavelength or a wavelength converting material 5 such as a filter material, etc., partly absorbing the light emitting wavelength thereby increasing the brightness, focussing efficiency due to the wavelength conversion light reflected on the cup 3.



CLAIMS

[Claim(s)]
[Claim 1]A light emitting diode which is provided with the following and characterized by a fluorescent substance which converts a luminous wavelength of a light emitting chip to other wavelength, or a filter substance which absorbs a part of luminous wavelength of a light emitting chip containing to said first resin.
First resin in which it is a light emitting diode which seals the whole light emitting device by which a light emitting chip was placed on a bottom part of a cup which reflects luminescence of a light emitting chip in the luminescence observation surface side by resin, and the aforementioned resin is filled up with the aforementioned inside of a cup.
Second resin which surrounds the first resin.

[Claim 2]The light emitting diode according to claim 1 which a substance contained in resin of said first resin is a fluorescent substance, and is characterized by filling up with said first resin so that it may become lower than the level surface of an edge of the aforementioned cup.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]The present invention is converted to wavelength which is applied to a light emitting diode (henceforth LED), especially is different in the luminous wavelength of a light emitting chip, or relates to LED which absorbs a part of luminescence of a light emitting chip.
[0002]
[Description of the Prior Art]Fig.2 is a schematic cross section showing one structure of the conventional LED, and the cup provided in order to reflect in a leadframe the light emitting chip in which 1 consists of compound semiconductors, and 2 and for 3 to reflect luminescence of a light emitting chip in the luminescence observation surface side, and 4 are resin which seals the whole light emitting device. Usually, highly transparent resin is chosen in order for the resin 4 to emit luminescence of a light emitting chip efficiently into the air, but. It is the purpose of converting the luminescent color of the light emitting chip to others, or the fluorescent substance which converts luminescence of a light emitting chip to other wavelength, or the filter substance 5 (henceforth the wavelength conversion material 5) which absorbs a part of luminous wavelength of a luminous wavelength may be mixed into the resin 4 in order to correct a color. In this case, usually it is mixed so that the wavelength conversion material 5 may be uniformly distributed to the resin 4.
[0003]
[Problem to be solved by the invention]However, when the wavelength conversion material 5 is uniformly distributed in the resin 4 for the above-mentioned purpose, as shown in this figure, the light by which wavelength changing was carried out, or the lights into which unnecessary wavelength was cut are scattered about in all directions in the resin 4, and there is a problem that condensing worsens. The arrow of Fig.2 is a figure showing typically signs that the light of a light emitting chip strikes upon the wavelength conversion material 5, and the lights by which wavelength changing was carried out are scattered about. That is, when the lights by which wavelength changing was carried out are scattered about, the light volume by the side of a luminescence observation surface decreases, and luminosity becomes low.
[0004]When the wavelength conversion material 5 is limited to a fluorescent substance, it approaches and LED of the different luminescent color is installed as a new problem, there is a problem of excessive luminescence of the fluorescent substance by other LED luminescence. For example, green LED which contains the fluorescent substance in which green emission is obtained with a blue light chip, If green LED is switched off and blue LED is turned on when it approaches horizontally on the same flat surface and the blue LED which consists only of a mere blue light chip is put in order, by the light which leaks and comes out of blue LED, and the light got blocked and scattered about, The fluorescent substance of green LED is excited, it will be in the state where green LED which went out lit up, and the mixed colors of both LED will occur.
[0005]Therefore, when the place made into the object of this invention makes resin of LED contain a wavelength conversion material and wavelength changing of a light emitting chip is performed, When a fluorescent pigment is used [and] for the purpose of improving condensing

of luminescence converted first and raising the luminosity of LED, it sets it as another purpose to provide LED to which mixed colors do not happen even if it approaches and installs LED from which wavelength differs.

[0006]

[Means for solving problem]The first resin in which LED of the present invention is LED which seals the whole light emitting device by which the light emitting chip was placed on the bottom part of the cup which reflects luminescence of a light emitting chip in the luminescence observation surface side by resin, and the aforementioned resin is filled up with the aforementioned inside of a cup, It consists of second resin which surrounds the first resin, and the fluorescent substance which converts the luminous wavelength of a light emitting chip to other wavelength, or the filter substance which absorbs a part of luminous wavelength of a light emitting chip contains to the above-mentioned first resin.

[0007]

[Function]In first resin for luminescence of a light emitting chip, it converts to desired wavelength or LED of the present invention absorbs a part of unnecessary wavelength. Thus, although the lights by which wavelength changing was carried out are scattered about in all directions, it is reflected by the cup and most scattered lights are condensed at the luminescence observation surface side. that is, since the cup of an application concerned reflects the light by which wavelength changing was carried out with the wavelength conversion material and can be condensed within first resin, the condensing efficiency of converted light is markedly alike, and improves.

[0008]If it is filled up with first resin containing a fluorescent substance so that it may become lower than the level surface of the edge of a cup when a wavelength conversion material is used as a fluorescent substance, the mixed colors between LED can be prevented by interrupting an incident light on the edge of a cup from the exterior, and not reaching even a fluorescent substance. If it says simply, when keeping the first resin that makes the cup depth deep and contains a fluorescent substance from overflowing a cup, the excitation source of a fluorescent substance can be restricted only to the luminous wavelength of a light emitting chip.

[0009]

[Working example]Fig.1 is a schematic cross section showing the structure of LED of one working example of an application concerned, and is taken as the structure which sealed the whole light emitting device which placed like Fig.2 the light emitting chip 1 which consists of compound semiconductors on the leadframe 2 which has the cup 3 by resin.However, a different place from Fig.2, sealing resin consists of the first resin 11 filled up with cup 3 inside, and the second resin 12 which surrounds the first resin, to the first resin 11, it converts to other wavelength or the wavelength conversion material 5 which is absorbed in part and to convert contains the luminous wavelength of the light emitting chip.

[0010]An identical material may be sufficient as the material of the first resin 11 and second resin, for example, it constitutes both from an epoxy resin, and should just make only first resin contain the fluorescent substance 5 in LED of the present invention. It cannot be overemphasized that it may be the same as that of the resin 4 of Fig.2. If the wavelength conversion material 5 is a fluorescent substance, fluorescent dye, a fluorescent pigment, a fluorescent substance, etc., As long as it is the material which can convert the luminous wavelength of a light emitting chip to other wavelength, what kind of thing may be used, If it is a filter substance, the unnecessary wavelength of luminescence of a light emitting chip will be absorbed, the material which receives color purity is chosen, and the inorganic and organic filter paints which usually have the same color as the luminescent color of a light emitting chip are used.

[0011]In order to obtain LED of such a structure, for example in an LED manufacturing process, pre dip the inside of a cup which placed the light emitting chip 1 previously by resin in order to usually drive out the air of the cup 3, but. It can obtain by making the first resin 11 contain the wavelength conversion material 5, when pre dipping, and sealing by the second resin 12, after the first resin 11 containing the wavelength conversion material 5 hardens. The first resin 11 that includes the wavelength conversion material 5 previously may be injected into cup 3 inside. thus, the inside of 3 of a cup is filled up with the first resin 11 containing the wavelength conversion material 5, most lights by which wavelength changing was carried out by the first resin 11 return in the reflector of the cup 3, and by reflecting in a luminescence observation surface, condensing of LED is markedly alike and improves.

[0012]The first resin 11 and the second resin 12 are used as a different material, and the external quantum efficiency of the light by which wavelength changing was carried out improves by setting up to make small the refractive index of the first resin 11 and the second resin 12 in order, and become close to the refractive index 1 of air. It cannot be overemphasized that a material smaller than the refractive index of the light emitting chip 1 is selected into the material of the first resin 11 in this case.

[0013]Fig.3 and Fig.4 are the schematic cross sections expanding and showing the portion of the cup 3 of LED concerning other working examples of the present invention, and the state with which Fig.3 became convex, the surface of the first resin 11 hardened it, and the cup 3 was filled up, and the state where Fig.4 became a concave conversely, and it hardened and filled up are shown.Since it fills up so that the first resin 11 containing the fluorescent substance may become lower than the level surface of the edge of the cup 3 and the cup 3 is not overflowed in which state when the wavelength conversion material 5 is used as a fluorescent substance, The extraneous light which excites a fluorescent substance by the edge of the cup 3 can be intercepted, and the mixed colors of LED can be prevented.

[0014]

[Effect of the Invention]As described above, since converted light reflects inside a cup since LED of the present invention has filled up the inside of a cup with first resin containing a wavelength conversion material, and it is condensed, luminosity improves more than double. When making first resin contain a fluorescent pigment, performing wavelength changing, making the cup depth deep and keeping first resin from overflowing a cup, When the mixed colors between LED do not occur, for example, a planar display is realized by LED, an image with dramatically sufficient resolution can be acquired.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The schematic cross section showing the structure of 1LED of the present invention.
[Drawing 2]The schematic cross section showing the structure of the conventional LED.
[Drawing 3]The schematic cross section expanding and showing the portion of the cup 3 of LED concerning other working examples of the present invention.
[Drawing 4]The schematic cross section expanding and showing the portion of Kapp 3 of LED concerning other working examples of the present invention.
[Explanations of letters or numerals]
1 ... Light emitting chip 2 ... Leadframe
3 ... Kapp 5 ... Wavelength conversion material
11 ... First resin 12 ... Second resin

[Translation done.]

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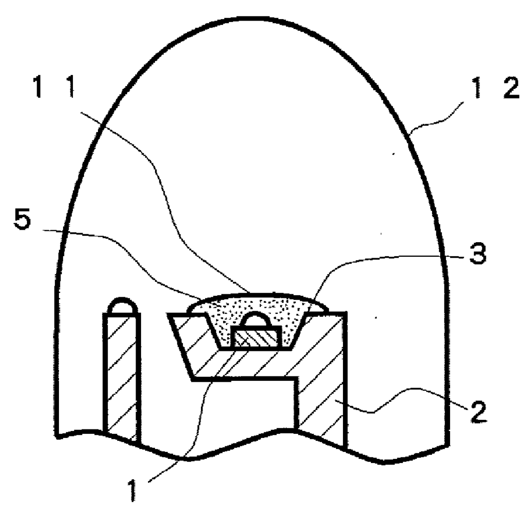
(54)【発明の名称】　発光ダイオード

(57)【要約】

【目的】　ＬＥＤの樹脂に波長変換材料を含有させて発光チップの波長変換を行う際、まず変換された発光の集光をよくしてＬＥＤの輝度を高めることを目的とし、また蛍光顔料を使用した際、波長の異なるＬＥＤを近接して設置しても混色の起こらないＬＥＤを提供する。

【構成】　ＬＥＤの封止樹脂が、カップ３内部を充填する第一の樹脂１１と、その第一の樹脂を包囲する第二の樹脂１２とからなり、第一の樹脂１１には発光チップの発光波長を他の波長に変換する蛍光物質、または発光波長を一部吸収するフィルター物質等の波長変換材料５が含有されていることにより、波長変換光がカップ３に反射されるため輝度、集光効率が向上する。



【特許請求の範囲】

【請求項1】　発光チップの発光を発光観測面側に反射するカップの底部に発光チップが載置された発光素子全体を、樹脂で封止してなる発光ダイオードであって、前記樹脂は前記カップ内部を充填する第一の樹脂と、その第一の樹脂を包囲する第二の樹脂とからなり、前記第一の樹脂には発光チップの発光波長を他の波長に変換する蛍光物質、または発光チップの発光波長を一部吸収するフィルター物質が含有されていることを特徴とする発光ダイオード。

【請求項2】　前記第一の樹脂の樹脂に含まれる物質が蛍光物質であって、前記第一の樹脂は前記カップの縁部の水平面よりも低くなるように充填されていることを特徴とする請求項1に記載の発光ダイオード。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は発光ダイオード（以下ＬＥＤという。）に係り、特に発光チップの発光波長を異なる波長に変換する、または発光チップの発光を一部吸収するＬＥＤに関する。

【0002】

【従来の技術】図２は従来のＬＥＤの一構造を示す模式断面図であり、１は化合物半導体よりなる発光チップ、２はリードフレーム、３は発光チップの発光を発光観測面側に反射させる目的で設けられたカップ、４は発光素子全体を封止する樹脂である。通常、樹脂４は発光チップの発光を空気中に効率よく放出する目的で透明度の高い樹脂が選択されるが、他にその発光チップの発光色を変換する目的で、あるいは色を補正する目的で、その樹脂４の中に発光チップの発光を他の波長に変換する蛍光物質、または発光波長の発光波長を一部吸収するフィルター物質５（以下、波長変換材料５という。）が混入される場合がある。この場合、波長変換材料５は樹脂４に均一に分散するように混入されるのが通常である。

【0003】

【発明が解決しようとする課題】しかしながら、上記の目的で波長変換材料５を樹脂４中に均一に分散させると、この図に示すように、波長変換された光、または不要な波長がカットされた光は樹脂４中で四方八方に散乱してしまい、集光が悪くなるという問題がある。図２の矢印は発光チップの光が波長変換材料５にあたり、波長変換された光が散乱する様子を模式的に示した図である。つまり、波長変換された光が散乱されることにより、発光観測面側の光量が減少して輝度が低くなるのである。

【0004】また、波長変換材料５を蛍光物質に限定した場合、新たな問題点として、異なる発光色のＬＥＤを接近して設置した際に、他のＬＥＤ発光による蛍光物質のよけいな発光の問題がある。例えば、青色発光チップで緑色発光が得られる蛍光物質を含む緑色ＬＥＤと、単

なる青色発光チップのみからなる青色ＬＥＤとを同一平面上に水平に近接して並べた場合、緑色ＬＥＤを消灯して、青色ＬＥＤを点灯すると、青色ＬＥＤから洩れ出る光、つまり散乱する光により、緑色ＬＥＤの蛍光物質が励起され、消灯した緑色ＬＥＤがあたかも点灯したような状態となり、両ＬＥＤの混色が発生する。

【0005】従って本発明の目的とするところは、ＬＥＤの樹脂に波長変換材料を含有させて発光チップの波長変換を行う際、まず変換された発光の集光をよくしてＬＥＤの輝度を高めることを目的とし、また蛍光顔料を使用した際、波長の異なるＬＥＤを近接して設置しても混色の起こらないＬＥＤを提供することをもう一つの目的とする。

【0006】

【課題を解決するための手段】本発明のＬＥＤは、発光チップの発光を発光観測面側に反射するカップの底部に発光チップが載置された発光素子全体を、樹脂で封止してなるＬＥＤであって、前記樹脂は前記カップ内部を充填する第一の樹脂と、その第一の樹脂を包囲する第二の樹脂とからなり、前記第一の樹脂には発光チップの発光波長を他の波長に変換する蛍光物質、または発光チップの発光波長を一部吸収するフィルター物質が含有されていることを特徴とする。

【0007】

【作用】本発明のＬＥＤは、発光チップの発光を第一の樹脂内において所望の波長に変換、または不要な波長を一部吸収する。このようにして波長変換された光は四方八方に散乱するが、散乱した光のほとんどはカップにより反射され、発光観測面側に集光される。つまり本願のカップは第一の樹脂内で波長変換材料により波長変換された光を反射して集光できるので、変換光の集光効率が格段に向上する。

【0008】さらに、波長変換材料を蛍光物質とした場合、蛍光物質を含む第一の樹脂をカップの縁部の水平面よりも低くなるように充填すると、外部から入射する光がカップの縁で遮られ、蛍光物質にまで到達しないことにより、ＬＥＤ間の混色を防止することができる。簡単にいうと、カップ深さを深くして蛍光物質を含む第一の樹脂がカップからはみ出さないようにすることにより、蛍光物質の励起源を発光チップの発光波長のみに制限できる。

【0009】

【実施例】図１は本願の一実施例のＬＥＤの構造を示す模式断面図であり、図２と同様に、カップ３を有するリードフレーム２上に化合物半導体よりなる発光チップ１を載置した発光素子全体を、樹脂で封止した構造としている。しかし、図２と異なるところは、封止樹脂がカップ３内部を充填する第一の樹脂１１と、その第一の樹脂を包囲する第二の樹脂１２とからなり、第一の樹脂１１には発光チップの発光波長を他の波長に変換、または一

部吸収する変換する波長変換材料５が含有されている。

【００１０】本発明のＬＥＤにおいて、第一の樹脂１１と第二の樹脂の材料は同一材料でもよく、例えば両方ともエポキシ樹脂で構成し、第一の樹脂にのみ蛍光物質５を含有させればよい。さらに、第二の樹脂１２の材料は図２の樹脂４と同一でもよいことはいうまでもない。また、波長変換材料５は蛍光物質であれば蛍光染料、蛍光顔料、蛍光体等、発光チップの発光波長を他の波長に変換できる材料であればどのようなものを使用してもよく、またフィルター物質であれば発光チップの発光の不要な波長を吸収し、色純度をよくする材料が選択され、通常発光チップの発光色と同一色を有する無機、有機のフィルター顔料が使用される。

【００１１】このような構造のＬＥＤを得るには、例えばＬＥＤ製造工程において、通常カップ３の空気を追い出す目的で、予め発光チップ１を載置したカップ内部を樹脂でプレディップするのであるが、プレディップする際に第一の樹脂１１に波長変換材料５を含有させておき、波長変換材料５を含む第一の樹脂１１が硬化した後、第二の樹脂１２で封止することにより得ることができる。また予め波長変換材料５を含む第一の樹脂１１をカップ３内部に注入してもよい。このようにして、波長変換材料５を含む第一の樹脂１１をカップの３の内部に充填し、第一の樹脂１１で波長変換された光のほとんどがカップ３の反射鏡内に戻り、発光観測面に反射することによりＬＥＤの集光が格段に向上する。

【００１２】また第一の樹脂１１と第二の樹脂１２とを異なる材料とし、第一の樹脂１１、第二の樹脂１２の屈折率を順に小さくして空気の屈折率１に近くなるように設定することにより波長変換された光の外部量子効率が向上する。なおこの場合、第一の樹脂１１の材料には、発光チップ１の屈折率よりも小さい材料を選定することは言うまでもない。

【００１３】図３、および図４は本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図であり、図３は第一の樹脂１１の表面が凸状になって硬化してカップ３に充填された状態、図４は逆に凹状となって硬化して充填された状態を示している。いずれの状態においても、波長変換材料５を蛍光物質とした場合、その蛍光物質を含む第一の樹脂１１がカップ３の縁部の水平面よりも低くなるように充填されており、カップ３からはみ出していないので、カップ３の縁部により蛍光物質を励起する外部光を遮断でき、ＬＥＤの混色を防止することができる。

【００１４】

【発明の効果】以上説明したように、本発明のＬＥＤはカップ内部に波長変換材料を含有する第一の樹脂を充填しているため、変換光がカップ内部で反射して集光されるため、輝度は倍以上に向上する。また、蛍光顔料を第一の樹脂に含有させて波長変換を行う場合、カップ深さを深くして、第一の樹脂がカップからはみ出さないようにすることにより、ＬＥＤ間の混色が発生せず、例えばＬＥＤで平面ディスプレイを実現した際には、非常に解像度のよい画像を得ることができる。

【図面の簡単な説明】

【図１】　本発明の一ＬＥＤの構造を示す模式断面図。

【図２】　従来のＬＥＤの構造を示す模式断面図。

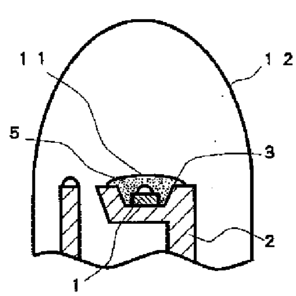
【図３】　本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図。

【図４】　本発明の他の実施例に係るＬＥＤのカップ３の部分を拡大して示す模式断面図。

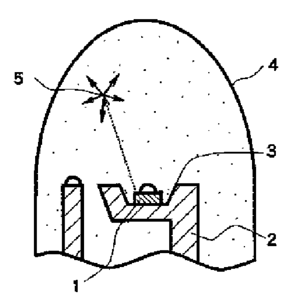
【符号の説明】

１・・・発光チップ　２・・・リードフレーム
３・・・カップ　５・・・波長変換材料
１１・・・第一の樹脂　１２・・・第二の樹脂

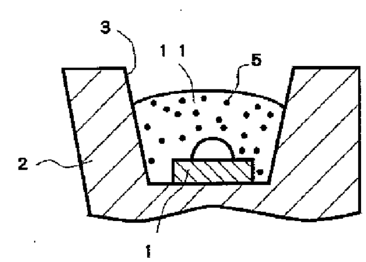
【図１】



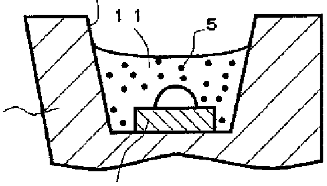
【図２】



【図３】



【図４】



フロントページの続き

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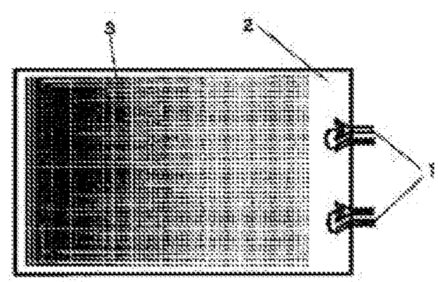
(72)Inventor : SHIMIZU YOSHINORI

(54) PLANAR LIGHT SOURCE

(57)Abstract:
PURPOSE: To provide a planar light source wherein a blue light emitting diode is used and white luminescence is feasible, and wherein uniform white luminescence can be observed.
CONSTITUTION: Light emitting diodes 1 are optically connected with the end of a transparent light transmitting plate 2. A fluorescent substance that emits light when energized by the luminescence of the blue light emitting diodes 1 and white powder that scatters fluorescence, are mixed. The resultant mixture is applied to either of the major surfaces of the light transmitting plate 2 to form a fluorescence scattering layer 3. The wavelength of the luminescence of the blue light emitting diodes 1 is changed through the fluorescence scattering layer 3.



CLAIMS

[Claim(s)]
[Claim 1]A fluorescent substance which a blue light-emitting diode is optically connected to at least one place of an end face of a transparent light guide plate, is further excited by luminescence of the aforementioned blue light-emitting diode by either of the main surfaces of the aforementioned light guide plate, and shows a fluorescence, A source of sheet-like light which having the fluorescence scattering layer applied where white powder over which fluorescence is scattered is mixed, carrying out wavelength changing of the luminescence of the aforementioned blue light-emitting diode by the aforementioned fluorescence scattering layer, and observing from the main surface side of a light guide plate of the aforementioned fluorescence scattering layer and an opposite hand.
[Claim 2]The source of sheet-like light according to claim 1, wherein the main-light-emission wavelength of the aforementioned blue light-emitting diode is shorter than 500 nm and a radiant power output is not less than 500 microwatts.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]The present invention relates to the source of sheet-like light which starts the light source of the surface state used for the backlight of a display, an illuminated operation switch, etc., especially can be preferably used as a backlight of a liquid crystal display.

[0002]
[Description of the Prior Art]EL and a cold cathode tube are used for the source of sheet-like light for the backlights of the liquid crystal display generally used for a notebook sized personal computer, a word processor, etc., for example. Itself of EL is a source of sheet-like light, a cold cathode tube is made into the source of sheet-like light using a diffusion board, and the luminescent color of the backlight of them is made white [most] now.
[0003]On the other hand, the light emitting diode (it is described as LED below.) is also used in part as a light source for backlights. However, by the former, when obtaining white light using LED, since there is only an about tens of microwatts radiant power output of blue LED, in order to realize white light using other red LED and green LED, there is a fault that a color change is large that it is hard to make the characteristic of these each color luminescence LED agree. Since those LED was recognized visually in the near position as a backlight even if trichromatic LED is gathered and it arranges in the same position geometrically on the same flat surface, it was impossible to have used a uniform white light source. Therefore, if large-sized, the actual condition is properly used with EL, and most backlights of white light using LED are not known by a cold cathode tube, small size - the medium size now at the white source of sheet-like light of the liquid crystal back light.
[0004]Although the trial which surrounds and carries out the convert colors of the circumference of a blue LED chip by resin containing a fluorescent substance also occurs partly as a light source of white light or monochrome, since a chip periphery is exposed to the beam of light of radiant intensity stronger than sunlight, degradation of a fluorescent substance poses a problem, especially it is remarkable at an organic fluorescent pigment. Organic dye of ionicity may cause an electrophoresis by direct-current electric field near the chip, and a color tone may change. Even if the conventional blue LED does not have sufficient output to carry out convert colors but carries out convert colors with a fluorescent substance, it is unusable.
[0005]
[Problem to be solved by the invention]The place which was accomplished in order that the present invention might solve such a fault, and is made into the purpose, Realize the source of sheet-like light which can be used mainly as a backlight and in which white light is possible using LED, and. It is in providing the source of sheet-like light which can observe uniform white light, and is in providing the source of sheet-like light which can emit light for arbitrary colors other than white further, using the characteristic of LED excellent in reliability, and using for various operation switches etc.
[0006]
[Means for solving problem]The fluorescent substance which blue LED is optically connected to

at least one place of the end face of a transparent light guide plate, and the source of sheet-like light of the present invention is further excited by luminescence of the aforementioned blue light-emitting diode by either of the main surfaces of the aforementioned light guide plate, and shows a fluorescence, The fluorescence scattering layer applied where the white powder over which light is scattered is mixed. (the main surface by the side of a fluorescence scattering layer is hereafter called second main surface.) -- it has, wavelength changing of a part of luminescence of the aforementioned blue light-emitting diode is carried out by the aforementioned fluorescence scattering layer, and it is observed from the main surface (main surface by the side of luminescence observation is called first main surface below.) side of the light guide plate of the aforementioned fluorescence scattering layer and an opposite hand

[0007]Fig.1 is the plan view which looked at the light guide plate 2 of the source of sheet-like light of the present invention from the fluorescence scattering layer 3 side. The light guide plate 2 consists of transparent materials, such as an acrylic and glass, and the light guide plate 2 and the blue LED 1 are optically connected by embedding the blue LED 1 under the end face of the light guide plate 2. that the blue LED 1 and the end face of the light guide plate 2 are connected optically in the present invention, Not to mention embedding the blue LED 1, as it says introducing the light of blue LED from the end face of the light guide plate 2, for example, is shown in this figure, if it says simply, It is realizable by adhering blue LED and leading luminescence of blue LED to the end face of the light guide plate 2 using an optical fiber etc.

[0008]Next, the fluorescence scattering layer 3 is scattering the fluorescence in the light guide plate 2 with the white pigment at the same time it comes to apply the ink which prepared the fluorescent substance and the white pigment and it carries out wavelength changing of the luminescence of the blue LED 1 with a fluorescent substance so that a desired color can be observed. So that the aforementioned fluorescence scattering layer 3 may especially be made into dot form by Fig.1 and the surface brightness by the side of a first main surface may become fixed. It is considered as a pattern which reduces the area of the fluorescence scattering layer 3 per unit area by the side of a second main surface, and area of the end of LED1 and the most distant second main surface is further made small a little slightly as compared with the maximum area as LED1 is approached. Here, ** in Fig.1 expresses the pattern of the fluorescence scattering layer 3. Although blue LED is made into the structure allotted to one end face two pieces in Fig.1, if a light guide plate is a quadrangle, to say nothing of connecting LED, the number of LED will not be limited to all end faces on all sides. The coating form of a fluorescence scattering layer and an application state can be suitably changed so that luminescence observed from the first main surface side may be made into surface state homogeneity according to the arrangement situation of LED.

[0009]

[Function]Fig.2 is a schematic cross section at the time of mounting the source of sheet-like light of the present invention as a backlight of a liquid crystal panel. The scatter reflection layer 6 which is on the second main surface side of the source of sheet-like light which this shows to Fig.1, for example from barium titanate, titanium oxide, an aluminum oxide, etc., For example, the light reflector with which the base 7 which consists of aluminum was laminated is installed, the optical diffuser 5 by which the surface is considered as unevenness at the first main surface side is installed, and these composition is not different from the backlight in particular that uses a light source as a cold cathode tube.

[0010]As the arrow of Fig.2 shows first, the light which came out of the blue LED 1 is emitted to the exteriors other than a light guide plate in part near the chip, but a great portion of light reaches the end face of a light guide plate in the inside of the light guide plate 2, repeating total internal reflection. It is reflected by the reflecting film 4 formed in all end faces, and the light which reached the end face repeats total internal reflection. At this time, a part of lights are absorbed with a fluorescent substance, and wavelength changing of them is carried out simultaneously, they are emitted [a part of lights are scattered about by the fluorescence scattering layer 3 provided at the second main surface side of the light guide plate 2 and], and the luminescent color observed from the first main surface side of the light guide plate 2 can observe the light which synthesized such lights. For example, in the source of sheet-like light which provided the fluorescence scattering layer 3 which consists of an orange fluorescent pigment and white pigment, by the operation described previously, the luminescent color from blue LED becomes white, and it can observe. A color tone can be arbitrarily adjusted with the kind of fluorescent substance, and the mixture ratio of a white pigment. At the present invention, the main-light-emission peak of especially the luminous wavelength of one blue LED is shorter than 500 nm, and the radiant power output needs not less than 200 microwatts of outputs of not less than 300 microwatts still more preferably. It is because it is in the tendency for the light source of surface state luminescence with sufficient uniform luminosity to be hard to be obtained even if it increases the number of blue LED which connects with the end face of a light guide plate optically even if when it becomes it difficult to realize all the colors that a luminous wavelength is not less than 500 nm and there are few the radiant power outputs than 200 microwatts.

[0011]

[Working example]

[Working example 1] The fluorescence scattering layer 3 was formed in one side of an acrylic board about 2 mm thick by screen-stencil by the dot form pattern shown in Fig.1. The fluorescent pigment which mixed ana product FAmade from SHINROIHI chemistry-001 whose fluorescence scattering layer 3 is a red fluorescent pigment, and the company's FA-005 which are green fluorescence paints, Barium titanate was mixed at a ratio of 1:5 by the weight ratio as white powder, and what distributed it in the acrylic binder was printed and formed.

[0012]Next, after cutting the acrylic board with which the fluorescence scattering layer was formed as mentioned above according to the desired pattern and grinding all the end faces (cutting plane) of an acrylic board, the light guide plate 2 with which the fluorescence scattering layer 3 was formed was obtained by forming the reflecting layer 4 which becomes a polished surface from aluminum.

[0013]Two places and a hole are provided to the end face of the aforementioned light guide plate 2, and it is a luminous wavelength of 480 nm to the hole. By embedding at a time one blue LED which consists of a gallium nitride system compound semiconductor which has 1200 microwatts of radiant power outputs, respectively, the source of sheet-like light of the present invention was acquired. When the blue LED of this source of sheet-like light was made to turn on simultaneously, substantially uniform white surface state luminescence which is a little tinged with yellowness was obtained from the luminescence observation surface side of the light guide plate 2. the place which installed the optical diffuser 5 by which mat processing was previously performed to the luminescence observation surface side, and the light reflector with which the barium titanate layer 6 was applied on the aluminum base 7 at the fluorescence scattering layer 3 side, and was used as the light source for backlights -- from the optical diffuser 5 side -- completely -- surface state -- uniform white light was obtained. Luminosity was 55cd/m^2.

[0014][Working example 2] Mix the fluorescence scattering layer 3 as yellow fluorescent dye, and the company's Orenge-240 is substantially mixed in equivalent amount as LumogenF Yellow-083 of BASF A.G., and orange fluorescent dye, When barium titanate was formed using the thing mixed at a ratio of 1(color):200 by the weight ratio as the fluorescent dye which dissolved them in butylcarbitol acetate, and a white substance and also the source of sheet-like light of the present invention was acquired like the working example 1, substantially uniform surface state luminescence was observed. When it was considered as the light source for backlights still more nearly similarly, completely uniform surface state luminescence was observed.

[0015]

[Effect of the Invention]As described above, the source of sheet-like light of the present invention became possible [realizing the source of sheet-like light by LED excellent in reliability] by having a fluorescence scattering layer containing the fluorescent substance which can moreover carry out wavelength changing to the surface of one of the two of a light guide plate by blue LED, and white powder using blue LED. And since the white powder of a

fluorescence scattering layer has the operation which reflects the light by which wavelength changing was carried out with the fluorescent substance, and makes it spread, there is little amount of the fluorescent substance used to be used, and it ends. Since an LED chip and a fluorescent substance do not meet with a convenient thing directly, there is little degradation of a fluorescent substance and it does not cause the tone change of the source of sheet-like light over a long period of time. Any color tones including white can be provided by changing the kind of a fluorescent substance and white powder, a mixed amount, etc. about a color tone.
[0016]When the radiant power output of the blue LED most preferably used as a side which excites a fluorescence scattering layer on the other hand considers it as a not less than 200-microwatt thing, wavelength changing can be efficiently carried out with a fluorescent substance, and the source of sheet-like light with a bright big area can be realized. Thus, the source of sheet-like light of an application concerned can also be used for the illuminated operation switch not only using the light source for backlights but a fluorescent substance, etc.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The plan view which looked at the light guide plate 2 of the source of sheet-like light of one working example of the present invention from the fluorescence scattering layer 3 side.
[Drawing 2]The schematic cross section at the time of mounting the source of sheet-like light of one working example of the present invention as a backlight.
[Explanations of letters or numerals]
1 ..... Blue LED
2 ..... Light guide plate
3 ..... Fluorescence scattering layer
4 ..... Reflecting layer
5 ..... Optical diffuser
6 ..... Scatter reflection layer
7 ..... aluminum base

[Translation done.]

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審査請求　未請求　請求項の数２　ＯＬ　（全４頁）

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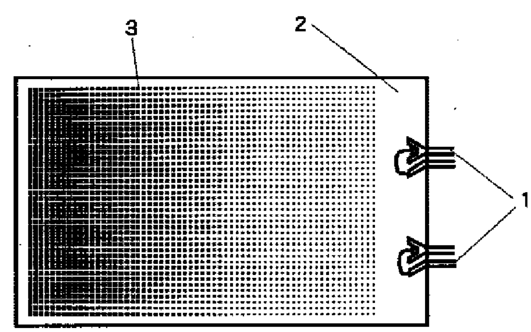
(54)【発明の名称】　面状光源

(57)【要約】

【目的】　青色発光ダイオードを用いた白色可能な面状光源を実現し、均一な白色発光を観測できる面状光源を提供する。

【構成】　透明な導光板の端面に発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換される。



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【特許請求の範囲】

【請求項１】　透明な導光板の端面の少なくとも一箇所に青色発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の主面側から観測されることを特徴とする面状光源。

【請求項２】　前記青色発光ダイオードは、その主発光波長が５００ｎｍよりも短く、発光出力が５００μＷ以上であることを特徴とする請求項１に記載の面状光源。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明はディスプレイのバックライト、照光式操作スイッチ等に使用される面状の光源に係り、特に液晶ディスプレイのバックライトとして好適に用いることができる面状光源に関する。

【０００２】

【従来の技術】一般にノート型パソコン、ワープロ等に使用される液晶ディスプレイのバックライト用の面状光源には、例えばＥＬ、冷陰極管が使用されている。ＥＬはそれ自体が面状光源であり、冷陰極管は拡散板を用いて面状光源とされ、現在それらのバックライトの発光色はほとんどが白色とされている。

【０００３】一方発光ダイオード（以下ＬＥＤと記す。）もバックライト用光源として一部利用されている。しかしＬＥＤを用いて白色発光を得る場合、従来では青色ＬＥＤの発光出力が数十μＷほどしかないため、他の赤色ＬＥＤ、緑色ＬＥＤを用いて白色発光を実現させるには、それら各色発光ＬＥＤの特性を合致させにくく色変化が大きいという欠点がある。また、三原色のＬＥＤを集合させて、同一平面上に幾何学的に同じ位置に配置しても、バックライトとしてはそれらのＬＥＤを接近した位置で視認するため、均一な白色光源にすることは不可能であった。従って現在白色の液晶バックライトの面状光源には、大型では冷陰極管、小型～中型にはＥＬと使い分けられているのが現状で、ＬＥＤを用いた白色発光のバックライトはほとんど知られていない。

【０００４】また白色発光、あるいはモノクロの光源として、一部では青色ＬＥＤチップの周囲を蛍光物質を含む樹脂で包囲して色変換する試みもあるが、チップ周辺は太陽光よりも強い放射強度の光線にさらされるため、蛍光物質の劣化が問題となり、特に有機蛍光顔料で顕著である。更にイオン性の有機染料はチップ近傍では直流電界により電気泳動を起こし、色調が変化する可能性がある。また従来の青色ＬＥＤは蛍光物質で色変換するには十分な出力を有しておらず、たとえ色変換したとしても実用できるものではなかった。

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【０００５】

【発明が解決しようとする課題】本発明はこのような欠点を解決するために成されたもので、その目的とするところは、ＬＥＤを用い、主としてバックライトとして利用できる白色発光可能な面状光源を実現すると共に、均一な白色発光を観測できる面状光源を提供することにあり、さらには白色以外の任意色の発光が可能な面状光源を提供し、信頼性に優れたＬＥＤの特性を利用し、各種操作スイッチ等に利用することにある。

【０００６】

【課題を解決するための手段】本発明の面状光源は、透明な導光板の端面の少なくとも一箇所に青色ＬＥＤが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層（以下、蛍光散乱層側の主面を第二の主面という。）を有し、前記青色発光ダイオードの発光の一部が前記蛍光散乱層で波長変換され、前記蛍光散乱層と反対側の導光板の主面（以下発光観測側の主面を第一の主面という。）側から観測されることを特徴とする。

【０００７】図１は本発明の面状光源の導光板２を蛍光散乱層３側から見た平面図である。導光板２は例えばアクリル、硝子等の透明な材料よりなり、その導光板２の端面に青色ＬＥＤ１が埋設されることにより、導光板２と青色ＬＥＤ１とが光学的に接続されている。なお本発明において、青色ＬＥＤ１と導光板２の端面とが光学的に接続されているとは、簡単に言えば、導光板２の端面から青色ＬＥＤの光を導入することをいい、例えばこの図に示すように青色ＬＥＤ１を埋設することはもちろんのこと、青色ＬＥＤを接着したり、また、光ファイバー等を用いて導光板２の端面に青色ＬＥＤの発光を導くことによって実現可能である。

【０００８】次に、蛍光散乱層３は、所望の色が観測できるように、蛍光物質と白色顔料とを調合したインクが塗布されてなり、青色ＬＥＤ１の発光を蛍光物質で波長変換すると同時に、白色顔料でその蛍光を導光板２内に散乱させている。特に図１では前記蛍光散乱層３をドット状とし、第一の主面側の表面輝度が一定となるように、ＬＥＤ１に接近するにつれて、第二の主面側の単位面積あたりの蛍光散乱層３の面積を減じるようなパターンとし、さらにはＬＥＤ１と最も離れた第二の主面の端部の面積はやや最大面積に比して若干小さくしている。ここで、図１中の■は蛍光散乱層３のパターンを表している。図１では青色ＬＥＤを一つの端面に２個配した構造としているが、導光板が四角形であれば四方の端面全てにＬＥＤを接続してもよいことはいうまでもなく、ＬＥＤの個数も限定するものではない。さらに、ＬＥＤの配置状況により、第一の主面側から観測する発光を面状均一とするように蛍光散乱層の塗布形状、塗布状態を適

宜変更することができる。

【０００９】

【作用】図２は本発明の面状光源を例えば液晶パネルのバックライトとして実装した場合の模式断面図である。これは図１に示す面状光源の第二の主面側に、例えばチタン酸バリウム、酸化チタン、酸化アルミニウム等よりなる散乱反射層６と、例えばＡｌよりなるベース７とが積層された反射板を設置し、第一の主面側に表面が凹凸とされている光拡散板５を設置しており、これらの構成は光源を冷陰極管とするバックライトと特に変わるものではない。

【００１０】まず図２の矢印で示すように、青色ＬＥＤ１から出た光は、チップ近傍で一部導光板以外の外部に放射されるが、大部分の光は導光板２の中を全反射を繰り返しながら、導光板の端面に達する。端面に達した光は端面全てに形成された反射膜４に反射されて、全反射を繰り返す。この時、導光板２の第二の主面側に設けられた蛍光散乱層３により一部の光は散乱され、また一部の光は蛍光物質により吸収され同時に波長変換されて放射され、導光板２の第一の主面側から観測する発光色はこれらの光を合成した光が観測できる。例えば橙色の蛍光顔料と白色顔料からなる蛍光散乱層３を設けた面状光源では、先に述べた作用により、青色ＬＥＤからの発光色が白色となって観測できる。また色調は蛍光物質の種類と白色顔料の混合比により任意に調整できる。特に本発明では一つの青色ＬＥＤの発光波長はその主発光ピークが５００ｎｍよりも短く、その発光出力は２００μＷ以上、更に好ましくは３００μＷ以上の出力が必要である。なぜなら発光波長が５００ｎｍ以上であると全ての色が実現しにくくなり、またその発光出力が２００μＷよりも少ないと、たとえ導光板の端面に光学的に接続する青色ＬＥＤの数を増やしても、充分な明るさの均一な面状発光の光源が得られにくい傾向にあるからである。

【００１１】

【実施例】

［実施例１］厚さ約２ｍｍのアクリル板の片面に、図１に示すドット状のパターンで、蛍光散乱層３をスクリーン印刷により形成した。蛍光散乱層３は、赤色蛍光顔料であるシンロイヒ化学製ＦＡ－００１と緑色蛍光顔料である同社製ＦＡ－００５とを等量に混合した蛍光顔料と、白色粉末としてチタン酸バリウムとを重量比で１：５の割合で混合し、それをアクリル系バインダー中に分散したものを印刷して形成した。

【００１２】次に上記のようにして蛍光散乱層が形成されたアクリル板を、所望のパターンに従って切断し、アクリル板の端面（切断面）を全て研磨した後、研磨面にＡｌよりなる反射層４を形成することにより、蛍光散乱層３が形成された導光板２を得た。

【００１３】前記導光板２の端面に二箇所、穴を設け、その穴に発光波長４８０ｎｍ。発光出力１２００μＷを有する窒化ガリウム系化合物半導体よりなる青色ＬＥＤをそれぞれ１個づつ埋め込むことにより、本発明の面状光源を得た。この面状光源の青色ＬＥＤを同時に点灯させたところ、導光板２の発光観測面側からはやや黄色みを帯びた白色のほぼ均一な面状発光が得られた。さらに、発光観測面側に予めマット加工が施された光拡散板５と、蛍光散乱層３側にＡｌベース７上にチタン酸バリウム層６が塗布された反射板を設置して、バックライト用光源としたところ、光拡散板５側から完全に面状均一な白色発光が得られた。輝度は５５ｃｄ／ｍ^{2}であった。

【００１４】［実施例２］蛍光散乱層３を、黄色蛍光染料としてＢＡＳＦ社のＬｕｍｏｇｅｎＦ　Ｙｅｌｌｏｗ－０８３と橙色蛍光染料として同社製Ｏｒｅｎｇｅ－２４０とをほぼ等量混合し、それらをブチルカルビトールアセテートに溶解した蛍光染料と、白色物質としてチタン酸バリウムとを重量比で１（染料）：２００の割合で混合したものを用いて形成する他は、実施例１と同様にして本発明の面状光源を得たところ、ほぼ均一な面状発光が観測された。さらに同様にしてバックライト用光源としたところ、完全に均一な面状発光が観測された。

【００１５】

【発明の効果】以上説明したように、本発明の面状光源は、青色ＬＥＤを用い、しかも導光板の片方の面に青色ＬＥＤにより波長変換できる蛍光物質と白色粉末とを含有した蛍光散乱層を有していることにより、信頼性に優れたＬＥＤによる面状光源を実現することが可能となった。しかも蛍光散乱層の白色粉末は、蛍光物質により波長変換された光を反射、拡散させる作用があるため、使用する蛍光物質の使用量が少なくて済む。更に好都合なことには、ＬＥＤチップと蛍光物質とが直接接することがないので、蛍光物質の劣化が少なく、長期間に渡って面状光源の色調変化を起こすことがない。さらに、色調に関しては、蛍光物質、白色粉末の種類、混合量等を変更することにより、白色を含め任意の色調を提供することができる。

【００１６】一方蛍光散乱層を励起する側として、最も好ましくは使用する青色ＬＥＤの発光出力が２００μＷ以上のものとすることにより、蛍光物質により効率的に波長変換して大きな面積の明るい面状光源を実現することができる。このように、本願の面状光源は、バックライト用光源とだけでなく、蛍光物質を利用した照光式操作スイッチ等に利用することもできる。

【図面の簡単な説明】

【図１】　本発明の一実施例の面状光源の導光板２を蛍光散乱層３側から見た平面図。

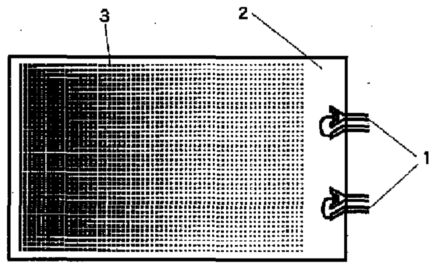
【図２】　本発明の一実施例の面状光源をバックライトとして実装した場合の模式断面図。

【符号の説明】

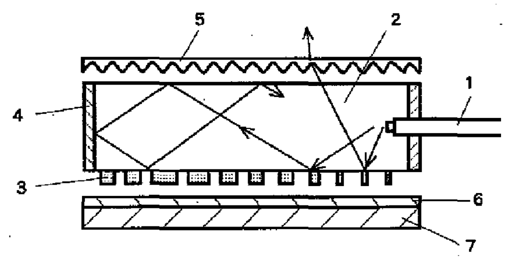
１・・・・・青色ＬＥＤ

2・・・・・導光板
3・・・・・蛍光散乱層
4・・・・・反射層
* 5・・・・・光拡散板
6・・・・・散乱反射層
* 7・・・・・Ａｌベース

【図1】



【図2】



Electronic Acknowledgement Receipt

EFS ID:	13454825
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/Patti Young
Filer Authorized By:	Corina E. Tanasa
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	09-AUG-2012
Filing Date:	14-SEP-2009
Time Stamp:	10:53:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20120809IDS.pdf	368676 d94db746fab00274b1f96a3e4a54633ff77d5cff	yes	8

	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	6	
	Information Disclosure Statement (IDS) Form (SB08)		7	8	
Warnings:					
Information:					
2	Foreign Reference	JP7335942.pdf	4167280 e6b0a788aceb9be939b6589012ea841896187e0a	no	11
Warnings:					
Information:					
3	Foreign Reference	JP7099345.pdf	3183622 a1bd8e4710ca48a4a2dfee2a92c61483d31b69bf	no	10
Warnings:					
Information:					
4	Foreign Reference	JP7176794.pdf	3820053 25b29adbd35b45886617abbc214cfac31a1af7b4	no	11
Warnings:					
Information:					
5	Non Patent Literature	SGSearchReportdated20120702.pdf	911518 1b085df251ebb0508859934ad038a61d0437b63d	no	13
Warnings:					
Information:					
6	Non Patent Literature	SGSearchReportdated20120705.pdf	714004 ad0e5dded079562712536b7360a5584242b40021	no	9
Warnings:					
Information:					
		Total Files Size (in bytes):	13165153		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. Copies of foreign patent documents, non-patent literature and other information are provided.

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date

12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract and a full English machine translation is provided (as a partial translation) for the following reference(s): JP 7-99345, JP 7-335942 and JP 7-176794.

☑ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION:

An English language version of a Singaporean Examination and Search Report issued on July 2, 2012 in foreign counterpart application No. 201007151-2 that indicates the degree of relevance is attached.

An English language version of a Singaporean Examination and Search Report issued on July 5, 2012 in foreign counterpart application No. 201007150-4 that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

JP 7-99345 and US 5,247,533 were cited in the Singaporean Examination and Search Report issued on July 2, 2012. US 3,691,482 cited in the Singaporean Examination and Search Report was previously cited in an IDS in USPTO.

JP 7-335942, JP 7-176794 and US 5,408,120 were cited in the Singaporean Examination and Search Report issued on July 5, 2012.

Both JP 7-99345 and JP 7-176794 were previously cited in an IDS filed in the USPTO on September 14, 2009. The full English machine translations for JP 7-99345 and JP 7-176794 are now submitted for Examiner's consideration.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed <u>before</u> the mailing date of a Final Office Action or <u>before</u> the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed <u>after</u> the mailing date of a Final Office Action or <u>after</u> the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. <u>PAYMENT OF FEES</u>

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: August 9, 2012

Respectfully submitted,

Reg. NO. 64042

By Corina Tanasa

for D. Richard Anderson

Registration No.: 40,439 CORINA TANASA

BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☑ Foreign Search Report
- ☐ Fee
- ☑ Other: Full English machine translations for JP 7-99345 and JP 7-176794.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number: Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2012/0132857 - A1	05-31-2012	Le Toquin	
	2	US-3,204,143	08-31-1965	Pritchard	
	3	US-3,882,502	05-06-1975	Peabody et al.	
	4	US-5,707,549	01-13-1998	Matsukiyo et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country[3] Code	Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	5	JP	2000-286455	10-13-2000	Nichia Chem. Ind. Ltd.		✔
	6	JP	48-39866	05-18-1973			
	7	JP	52-40959	10-15-1977			
	8	JP	53-43885	04-14-1978			
	9	JP	7-193281	07-28-1995	Mitsubishi Materials Corp.		✔

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

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PTO/SB/08b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 2 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	10	"An Experimental Result of Packages Having Different Phosphors and Colloids", pp. 374-384.	
	11	"Measurement Service Report", prepared by Industrial Technology Research Institute in Taiwan, pp. 298-358, May 4, 2012.	
	12	E-mail correspondences sent from Dow Corning Toray Co., Ltd. to the requester of the cancellation action, September 28, 2011.	
	13	Phosphor Handbook, pp. 5-11, published December 25, 1987.	
	14	Request for Invalidation with Notification of Acceptance of Request for Invalidation of CN Patent No. 200610095837.4 issued on September 10, 2012 in a counterpart Chinese application.	
	15	US Office Action issued in copending US Application No. 12/575,155 on October 4, 2012.	
	16	US Office Action issued in copending US Application No. 12/689,681 on September 7, 2012.	
	17	US Office Action issued in copending US Application No. 12/947,470 on November 15, 2012.	
	18	US Office Action issued in copending US Application No. 13/210,027 on October 2, 2012.	

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

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PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2000-286455
(43)Date of publication of application : 13.10.2000

(51)Int.Cl. H01L 33/00
H01L 21/56
H01L 23/29
H01L 23/31

(21)Application number : 11-039262
(22)Date of filing : 17.02.1999

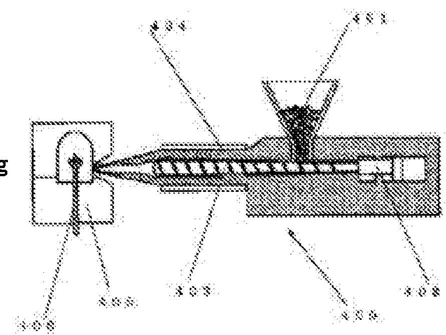
(71)Applicant : NICHIA CHEM IND LTD
(72)Inventor : TAMEMOTO HIROAKI

(30)Priority

Priority number	Priority date	Priority country
10035273	17.02.1998	JP
11023234	29.01.1999	JP

(54) LIGHT EMITTING DIODE AND METHOD FOR FORMING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a light emitting diode which utilizes a high yield phosphor having less unevenness in luminosity or color nor luminous dispersion among light emitting diodes.
SOLUTION: A luminous element 103 and a translucent resin 101 comprising a phosphor 102, which absorbs at least a part of the luminous wavelength from the luminous element 103 and emits fluorescence, are provided to a light emitting diode 100, which emits a mixed light of the light from the luminous element 103 and fluorescent from the phosphor 102. The translucent resin 101 is a light emitting diode, wherein at least a part of the luminous element 103 is coated through injection molding.



CLAIMS

[Claim(s)]
[Claim 1]It is a light emitting diode which has a light emitting device and translucency resin containing a fluorescent substance which absorbs at least one copy of a luminous wavelength from this light emitting device, and shows a fluorescence, and emits light in light from the aforementioned light emitting device, and mixed-colors light of fluorescence from a fluorescent substance, A light emitting diode which translucency resin containing the aforementioned fluorescent substance covers at least one copy of a light emitting device with injection moulding, and is characterized by things.
[Claim 2]A light emitting device.
Translucency resin containing a fluorescent substance which absorbs at least one copy of a luminous wavelength from this light emitting device, and shows a fluorescence.
In a formation method of a light emitting diode provided with the above,
A formation method of a light emitting diode injection molding translucency resin containing the aforementioned fluorescent substance, and covering at least one copy of a light emitting device.

[Claim 3]In a formation method of a light emitting diode which has a light emitting device and translucency resin containing a fluorescent substance which absorbs at least one copy of a luminous wavelength from this light emitting device, and shows a fluorescence, and emits light in light from the aforementioned light emitting device, and mixed-colors light of fluorescence from a fluorescent substance,
A formation method of a light emitting diode characterized by comprising the following.
A process of making the aforementioned translucency resin into a solid state which made a fluorescent substance containing uniformly substantially.
A process of softening translucency resin of fluorescent substance content used as this solid state, and covering at least one copy of a light emitting device.
A process of making translucency resin of the aforementioned fluorescent substance content into a solid state again.

[Claim 4]A formation method of the light emitting diode according to claim 2 or 3 which is the yttrium aluminum garnet system fluorescent substance in which a luminous layer of the aforementioned light emitting device consisted of nitride semiconductors at least, and the aforementioned fluorescent substance was activated with cerium.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]The present invention relates to the light emitting diode which converts at least one copy of the luminous wavelength emitted from a light emitting device with a fluorescent substance, and emits it, and luminescence unevenness, an irregular color, and the luminescence variation between the formed light emitting diodes are especially related with few high light emitting diodes of the yield.
[0002]
[Description of the Prior Art]A semiconductor light emitting element carries out luminescence of a small and efficient skillful color. Since it is a semiconductor device, there is no burn-out. The drive characteristic is excellent and it has the characteristics that it is strong to a repetition of vibration and ON/OFF lighting. Therefore, it is used as various indicators or various light sources. However, when only luminescence of white systems (white, pink, a bulb color, etc.) was obtained although such a light emitting device had monochromatic peak wavelength therefore, it could not but use two or more kinds of light emitting devices. The various luminescent color was not able to be obtained easily.
[0003]What was described in JP,H7-99345,A etc. is known as a light emitting diode which makes the various luminescent color emit light using the LED chip and fluorescent substance which emit monochromatic peak wavelength. These light emitting diodes can consist of resin with which the light emitting chip was made to load into Kapp's bottom part which reflects luminescence of a light emitting chip in the luminescence observation surface side, and the inside of Kapp was filled up, and resin which covered the whole. The light from a light emitting chip is absorbed and the fluorescent substance which carries out wavelength changing is made to have contained in the resin with which the inside was filled up.
[0004]On Kapp carried in the light emitting device, the resin which the fluorescent substance contained carries out a dropping injection, carries out heat cure of the liquefied epoxy resin etc., and let it be a convert-colors component. Resin other than the inside of Kapp carries out immersion arrangement of the frame member tip where the convert-colors component and the light emitting chip were formed in the casting case which carried out casting of the liquefied epoxy resin etc., and forms it by putting this into oven and carrying out heat cure. Thereby, it can be considered as the light emitting diode which carried out wavelength changing of the luminous wavelength from a light emitting chip with the fluorescent substance. For example, the yellow system which absorbs the light and the light of a blue system of a blue system from an LED chip, and is in complementary color relation can be used as the light emitting diode with which white can emit light with mixed colors with the light from the fluorescent substance which emits light.
[0005]In order to make a desired white system etc. emit light using such a light emitting diode, it is necessary to make each light emit light with very sufficient accuracy, and to carry out mixed-colors adjustment. The light from an LED chip can be made to adjust according to the semiconductor, driving current, etc. When the light by which wavelength

changing was carried out from the fluorescent substance, on the other hand, also controls composition and the particle diameter of a fluorescent substance, it can adjust to some extent.
[0006]
[Problem to be solved by the invention]However, there is no adhesion power in the fluorescent substance itself, or since it is weak, in order to carry out disposition and fixation on a light emitting device, it is necessary to make it contain in the binder which has the adhesion which can emit the light of light emitting devices, such as inside of various resin, and each fluorescent substance. The light volume emitted from the light volume and the fluorescent substance in which the fluorescent substance contained in such a binder was emitted by the content of the fluorescent substance, distribution, etc. from the LED chip is influenced largely. When the visible light which cannot control these and is emitted from a light emitting device, and the light emitted from a fluorescent substance carry out a color expression with the mixed colors of visible light, the difference in each visible light volume poses a big problem. Since especially a white system is discriminable also with few [human being's eyes] color temperature differences, it poses a big problem. Therefore, it is in providing the high light emitting diode of the yield which the present invention solved [light emitting diode] the above-mentioned problem, and improved [accuracy] content of a fluorescent substance, and distribution extremely that it is uniform, and was excellent in emitting properties.
[0007]
[Means for solving problem]In the light emitting diode with which various inventors used the fluorescent substance as a result of the experiment, the irregular color and luminescence unevenness of the variation between light emitting diodes or a light emitting diode find out that it can control by originating in distribution of a fluorescent substance largely, and a specific formation method, and came to accomplish the present invention.
[0008]That is, when the light emitting device has been arranged, and also the liquefied translucency resin which the fluorescent substance contained is injected and it makes it form, in consideration of the filling properties in casting, the thing of the hypoviscosity whose viscosity is about 500-1000 cps is used. Since the specific gravity of a fluorescent substance and resin differs largely, if a fluorescent substance is mixed in such translucency resin, both will separate easily. Therefore, it floats, when a light organic fluorescent substance etc. are used, and when a heavy inorganic fluorescent material etc. are used, it tends to sediment. Such separation produces the distributed unevenness of a fluorescent substance.
[0009]When repeating and manufacturing especially the method of carrying out every casting of a little mixtures which mixed the fluorescent substance with resin to a batch type, separation of resin of a mixture and a fluorescent substance advances with time. Therefore, it is in the tendency for the content of a fluorescent substance to differ, in the light emitting diode manufactured by carrying out casting immediately after mixing, and the light emitting diode manufactured by carrying out casting for a while after mixing behind.
[0010]In connection with temperature rise, viscosity is deteriorated until resin solidifies, when carrying out heat cure of the light emitting diode which casting completed. Therefore, it is in the tendency which separation by the specific gravity difference of resin and a fluorescent substance tends to generate also within a casting case. In the light emitting diode which makes the mixed-colors light of visible luminescence and the visible fluorescence from a fluorescent substance from a light emitting device emit light especially, all of content change of a fluorescent substance and the distribution unevenness within sealing resin appear notably as color temperature change of the luminescent color. Such a problem is solvable by the following present invention. That is, the present invention is a light emitting diode which has translucency resin containing the fluorescent substance which absorbs at least one copy of the luminous wavelength from a light emitting device and a light emitting device, and shows a fluorescence, and emits light in the light from a light emitting device, and the mixed-colors light of the fluorescence

from a fluorescent substance. Especially translucency resin covers at least one copy of a light emitting device with injection moulding. It can be considered as the light emitting diode with sufficient controllability in which uniform light emission is possible by this.
[0011]The formation method of the light emitting diode of the present invention according to claim 2 is a formation method of the light emitting diode which forms translucency resin containing the fluorescent substance which absorbs at least one copy of the luminous wavelength from a light emitting device, and shows a fluorescence by injection moulding on a light emitting device. The light emitting diode which mixed the fluorescent substance very uniformly and whose optical characteristic was stable in sealing resin of the formed light emitting diode by this is obtained.
[0012]The formation method of the light emitting diode of the present invention according to claim 3 is a formation method of the light emitting diode which has a light emitting device and translucency resin containing the fluorescent substance which absorbs at least one copy of the luminous wavelength from a light emitting device, and shows a fluorescence, and emits light in the light from a light emitting device, and the mixed-colors light of the fluorescence from a fluorescent substance. The process of making especially translucency resin into the solid state which made the fluorescent substance containing uniformly substantially, It is a formation method of the light emitting diode which has the process of softening translucency resin of the fluorescent substance content used as a solid state, and covering at least one copy of a light emitting device, and the process of making translucency resin of the aforementioned fluorescent substance content into a solid state again.
[0013]The luminous layer of a light emitting device consists of nitride semiconductors at least, and the formation method of the light emitting diode of the present invention according to claim 4 is the yttrium aluminum garnet system fluorescent substance (it may be hereafter called a YAG phosphor.) by which the fluorescent substance was activated with cerium. Thereby, the variation between the formed light emitting diodes can make the light emitting diode with which less white light with few luminescence unevenness and irregular colors can emit light form.
[0014]
[Mode for carrying out the invention]The typical cross sectional view of the light emitting diode 100 in which white light is possible is shown in Fig.1 as a light emitting diode by the example of an embodiment of the present invention. It has the Kapp upper part which carries an LED chip at the tip of the mount lead 104 at which plating treatment, such as silver or gold, was performed to the surface of copper or an iron system alloy. Alone, the carried LED chip is the light emitting device 103 which emits light in the visible light of a blue system, and mount fixation is carried out with the epoxy resin used as the mount member 106. Each electrode of the light emitting device 103 is carrying out wire bond combination with the mount lead 104 and the inner lead 105 with the wire 107 consisting of gold etc. It has sealed as the translucency resin 101 excellent in heat resistance with thermosetting resin, such as thermoplastics, such as norbornene system resin, polymethyl pentene resin (TPX), and amorphous nylon resin, cycloaliphatic epoxy resin, and a nitrogen-containing epoxy resin. Into translucency resin, an exposure of blue glow has done about 5 mass % mixing of YAG phosphor 102 activated by Ce which shows a yellow fluorescence.
[0015]A light emitting diode inserts an LED chip to a leadframe, and inserts mount and the thing which carried out the wire bond to a molding die, The thing accommodated while one piece stirred in the hopper resin and the YAG phosphor of the pellet type which are tens of mm^3 degrees, or the thing which mixed the YAG phosphor in the resin pellet previously is injection molded and sealed with the injection molding machine accommodated in the hopper. Heat melting and the resin which carried out stirring feeding, injected resin in the mold, and was injected in the mold are promptly cooled in a short time for about several seconds within the screw of a briquetting machine, and injection molding solidifies resin in

tens of seconds.
[0016]Translucency resin is made with a solid state in the molding previous state in the present invention. If the resin pellet and the fluorescent substance are uniformly mixed before briquetting machine supply, the fluorescent substance in resin will not sediment or float freely like a liquid. Therefore, the mixed state of a fluorescent substance is held as [before supplying in a mold / state]. As compared with tens of seconds and several hours of the method of carrying out heat-curing formation by cast molding, it is very short from several minutes during the period which resin carries out melting at the time of molding, and exists with a liquid. When are ejected and application-of-pressure stirring is carried out with a screw, distribution of the fluorescent substance in the inside of resin can be made more into homogeneity. The time to solidification is also very short and separation with resin and a fluorescent substance is hardly generated, either.
[0017]That is, it is very hard to generate separation with resin and a fluorescent substance before post forming solidification before molding. Thereby, with the light emitting diode of the present invention, it cannot be based on the specific gravity difference of resin and a fluorescent substance, but uniform dispersion can be carried out into resin. Therefore, there is not only the distribution homogeneity of the fluorescent substance in a light emitting diode but very little content variation of the fluorescent substance for every manufacture lot.
[0018]When it is considered as the light emitting diode in which the white light which contained especially the YAG:Ce fluorescent substance as a fluorescent substance is possible, compared with resin, the thing of always very uniform distribution is made also with a YAG:Ce fluorescent substance with large specific gravity. Therefore, a light emitting diode with a uniform color temperature can form stably. Hereafter, each composition used for the present invention is explained in full detail.
[0019](Injection molding machine 400) Since heat melting of the translucency resin of the fluorescent substance content like Fig.4 is carried out and it is made to eject and mold in the mold 405 through a nozzle as the injection molding machine 400 used for the present invention by the plunger 402, it is used preferably. Therefore, the injection molding machine can mainly consist of molds which give the form of the nozzle which leads in a mold the melting resin extruded by the plunger for carrying out softening melting of the pellet 401 of the translucency resin which a fixed quantity of fluorescent substances contained previously, and ejecting it, and a plunger, and a cast. When [with the fluorescent substance which a light emitting diode is especially excited by the visible light from a light emitting device, and this visible light, and emits light] carrying out mixed-colors luminescence, if the amounts of mixed distribution differ also with a very small amount very much, change of that luminescent color will become largely. Therefore, it is preferable to carry out churning melting of the translucency resin which the fluorescent substance contained using preplasticization equipment etc. Such churning can be variously performed [target / continuous, / intermittent], unless the density of the fluorescent substance contained in translucency resin changes. Churning rotational speed can be made to choose variously according to a size of the screw 403, the particle diameter and form of a fluorescent substance, viscosity of a binder, construction material, etc. used as an agitating part.
[0020](Translucency resin 101) The translucency resin used for the present invention is resin which makes an inside contain a fluorescent substance and can take fixed form by injection. Specifically Norbornene resin, polymethyl pentene resin, amorphous nylon resin, The thermoplastics which has translucency, such as polyarylate and polycarbonate resin, and was excellent in heat resistance, 100 degrees C to 260 degree-C degrees, such as polyamide and vinyl acetate, comparatively Low temperature, Injection moulding of a 1 to 25 Kgf/cm^2 degree comparatively called what is called hot melt molding with low pressure is possible, and the thermosetting resin which has translucency, such as thermoplastics and cycloaliphatic epoxy resin, and a nitrogen-containing epoxy resin, is mentioned

preferably. It can be considered as the pellet used as the charge of a softening melting material of injection formation, etc. by carrying out melting distribution of the fluorescent substance, and making it form into these resin at a fixed size. These translucency resin can be made to contain various additive agents, such as colorant which cuts desired wavelength, a dispersing agent which makes a desired light diffuse, an ultraviolet ray absorbent which improves the lightfastness of resin, an antioxidant, and a hardening accelerator.

[0021](Fluorescent substance 102) The fluorescent substance which is excited as a fluorescent substance used for the present invention by the electromagnetic waves which emitted light from the light emitting device, and shows a fluorescence is said. As for a fluorescent substance, generally, it is more preferable than a luminous wavelength that excited wavelengths use the fluorescent substance which shows a fluorescence of long wavelength rather than the luminous wavelength from a light emitting device since the direction of short wavelength is efficient. In order to make white emit light with mixed colors with the blue light emitting device as a specific fluorescent substance, various things, such as zinc selenide activated with the yttrium aluminum garnet system fluorescent substance, the perylene system derivative, and copper which were activated with cerium, are mentioned. Especially an yttrium aluminum garnet system fluorescent substance is preferable especially from viewpoints of lightfastness, efficiency, etc., when a nitride semiconductor is used for a light emitting device.

[0022]The yttrium aluminum garnet system fluorescent substance activated with cerium can be strong for heat, light, and moisture, and the peak of an excitation spectrum can make it carry out near 450 nm for garnet structure. The broadcloth emission spectrum in which a light emission peak is also near 530 nm, and the skirt is pulled to 700 nm can be given. With the yttrium aluminum garnet system fluorescent substance activated with cerium in the present invention, It can replace with at least 1 type chosen from Lu, Sc, La, Gd, and Sm instead of yttrium (Y) of Y_3aluminum$_5O_{12}$:Ce as what is most interpreted in a broad sense. It can replace with at least 1 type chosen from Ga, In, B, and Tl instead of aluminum (aluminum). It is possible to adjust the luminescent color continuously by changing composition. That is, it has the ideal condition for converting blue system luminescence of a nitride semiconductor — the strength by the side of long wavelength is continuously changed by the composition ratio of Gd — to white system luminescence. Lu, Lc, Sc, Sm, etc. are added and it may be made similarly to obtain the desired characteristic.

[0023]An oxide or the compound which turns into an oxide easily at an elevated temperature is used for such a fluorescent substance as a raw material of Y, Gd, Ce, Sm, La, aluminum, and Ga, it mixes them sufficiently by a stoichiometric ratio, and obtains a raw material. Or the coprecipitated oxide produced by calcinating what carried out the coprecipitation of Y, Gd, Ce, Sm, and the solution that dissolved the rare earth element of La in acid by the stoichiometric ratio with oxalic acid, and an aluminum oxide and gallium oxide are mixed, and a mixed raw material is obtained. A proper quantity of fluorides, such as ammonium fluoride, are mixed as flux to this, crucible is stuffed, it can calcinate in the temperature requirement of 1350-1450 degreein the air C for 2 to 5 hours, a burned product can be obtained, and it can obtain by carrying out the ball mill of the burned product underwater next, and letting a screen pass at washing, separation, drying, and the last.

[0024]In the light emitting diode of the present invention, two or more kinds of such fluorescent substances may be mixed. It can perform mixing the yttrium aluminum garnet system fluorescent substance specifically activated with two or more kinds of cerium in which the content of aluminum, Ga, Y and Gd, La, or Sm differs, and increasing the wavelength component of RGB etc. In such a case, even if the specific gravity between different fluorescent substances differs, the uniform light emitting diode of emitting properties with sufficient mass production nature can be formed.

[0025](Light emitting devices 103 and 203) In the light emitting device 103 used for the present invention, it is a semiconductor light emitting element which has a luminous layer which can emit light in the luminous wavelength which can excite a fluorescent substance. Although various semiconductors, such as ZnSe and GaN, can be mentioned as such a semiconductor light emitting element, the nitride semiconductor (In_Xaluminum$_Y Ga_{1-X-Y}N$, 0<=X, 0<=Y, X+Y<=1) with which the short wavelength which can excite a fluorescent substance efficiently can emit light is mentioned preferably. As a structure of a semiconductor, the thing of terrorism composition is mentioned to the gay structure, hetero structure, or double which has MIS junction, PIN junction, pn junction, etc. Various luminous wavelengths can be chosen with the material and its degree of mix crystal of a semiconductor layer. A semiconductor active layer can also be made into the single quantum well structure and multiple quantum well structure which were made to form in the thin film which a quantum effect produces.
[0026]When a nitride semiconductor is used, materials, such as sapphire, a spinel, SiC, Si, and ZnO, are preferably used for the substrate for semiconductors. In order to make a good crystalline nitride semiconductor form with sufficient mass production nature, it is preferable to use a sapphire substrate. The MOCVD method etc. can be used for this sapphire substrate Kami, and a nitride semiconductor can be made to form. Buffer layers, such as GaN, AlN, and GaAlN, are formed in silicon-on-sapphire Kami, and the nitride semiconductor which has pn junction is made to form on it.
[0027]As an example of a light emitting device which it has, the pn junction which uses a nitride semiconductor to buffer layer Kami, The first contact layer formed by n type gallium nitride, the first cladding layer made to form by n type aluminum-nitride gallium, Terrorism composition etc. are mentioned to the double which made the active layer formed by indium nitride gallium, the second cladding layer formed by p type aluminum-nitride gallium, and the second contact layer formed by p type gallium nitride laminate in order.
[0028]A nitride semiconductor shows n type conductivity in the state where an impurity is not doped. When making the n type nitride semiconductor of a request, such as improving luminous efficiency, form, it is preferable to introduce Si, germanium, Se, Te, C, etc. suitably as a n type dopant. On the other hand, when making a p type nitride semiconductor form, Zn, Mg, Be, Ca, Sr, Ba, etc. which are p type dopants are made to dope. Only by doping a p type dopant, since itis [p-type-] hard toize a nitride semiconductor, it is preferable to make it low-resistance-ize by heat-treating by heating, plasma irradiation, etc. at a furnace after p type dopant introduction. The light emitting device consisting of a nitride semiconductor can be made to form by making it cut into chip shape from a semiconductor wafer after electrode formation.
[0029]When making a white system emit light in the light emitting diode of the present invention, as for the luminous wavelength of a light emitting device, in consideration of complementary color relation with the luminous wavelength from a fluorescent substance, degradation of translucency resin, etc., not less than 400 nm 530 nm or less is preferable, and not less than 420 nm 490 nm or less is more preferable. In order to improve more excitation with a light emitting device and a fluorescent substance, and luminous efficiency, respectively, not less than 450 nm 475 nm or less is still more preferable. It cannot be overemphasized that the wavelength of an ultraviolet area shorter than 400 nm can be used.
[0030](Mount leads 104 and 204) As the mount lead 104, a light emitting device is arranged and there should just be sufficient size to load by die-bonded apparatus etc. When installing two or more light emitting devices and using a mount lead as a common electrode of a light emitting device, sufficient electrical conductivity and connectivity with a bonding wire etc. are called for. When arranging a light emitting device in the cup on a mount lead and making an inside fill up with a fluorescent substance, it can prevent carrying out false lighting by the light from another light emitting diode approached and arranged.

[0031]Thermosetting resin etc. can perform adhesion with a light emitting device and the cup of a mount lead as the mount member 106. Specifically, an epoxy resin, an acrylic resin, silicon resin, imide resin, etc. are mentioned. In order to make it adhere with a mount lead by a flip chip type light emitting device and to make it electrically connect, the resin etc. which Ag paste, Cu paste, carbon paste, and a metallic bump and a metallic oxide contained can be used. As specific electrical resistance of a mount lead, below 300micro ohm-cm is preferable, and it is below 3micro ohm-cm more preferably. When loading two or more light emitting devices on a mount lead, since the calorific value from a light emitting device increases, it is called for that thermal conductivity is good. Specifically, more than 0.01 $cal/cm^2/cm$/** are 0.5 $cal/cm^2/cm$ / more than ** preferable more preferably. As a material which fulfills these conditions, ceramics with iron, copper, copper containing iron, copper containing tin, and a metallizing pattern, etc. are mentioned.
[0032](Inner leads 105 and 205) As an inner lead, connection is electrically aimed at via a light emitting device, a conductive wire, etc. which are arranged on a mount lead. It is called for that connectivity and electrical conductivity of an inner lead with a bonding wire etc. are good. As specific electrical resistance, below 300micro ohm-cm is preferable, and it is below 3micro ohm-cm more preferably. As a material which fulfills these conditions, aluminum, iron, copper, etc. which plated iron, copper, copper containing iron, copper containing tin and copper, gold, and silver are mentioned.
[0033](Wires 107 and 207) As the wire 107, what has good ohmic nature with the electrode of a light emitting device, adhesion, electrical conductivity, and thermal conductivity is called for. As thermal conductivity, more than 0.01 $cal/cm^2/cm$/** are preferable, and they are 0.5 $cal/cm^2/cm$ / more than ** more preferably. In consideration of workability etc., the diameter of a wire is preferable, and they are more than phi10micrometer and less than phi45micrometer. The wire using metal and those alloys, such as gold, copper, platinum, and aluminum, specifically as such a wire is mentioned. Such a wire can connect easily an electrode, an inner lead, a mount lead of each light emitting device, etc. by wirebonding apparatus.
[0034](Molding member 208) The molding member 208 can be provided in order to protect the light emitting device 103, the wire 107, the fluorescent substance 102, etc. from outside according to the usage of a light emitting diode. A molding member can be made to form using resin generally. Although an angle of visibility can be increased by making a fluorescent substance contain, by making a resin molding contain a dispersing agent, the directivity from a light emitting device can be made to be able to ease, and an angle of visibility can be increased further. The lens effect it converge luminescence from a light emitting device, or is made to diffuse can be given by making a molding member into desired form again. Therefore, the structure which carried out plural laminates may be sufficient as a molding member. It is the thing which saw from convex lens form, concave-lens form, and also a luminescence observation surface, and combined two or more elliptical and them specifically. As a specific material of a molding member, transparent resin, glass, etc. which were mainly excellent in weatherability, such as an epoxy resin, a urea resin, and silicone resin, are used preferably. As a dispersing agent, barium titanate, titanium oxide, an aluminum oxide, a silicon oxide, etc. are used preferably. A molding member and a binding agent may be made to form using the thing of the same construction material in consideration of refractive index difference. It cannot be overemphasized that it is not hereafter limited only to this although the specific working example of the present invention is explained in full detail.
[0035]
[Working example](Working example 1) The $In_{0.2}Ga_{0.8}N$ semiconductor whose light emission peak is 450 nm was used for the LED chip as a luminous layer. The LED chip passed TMG (trimethylgallium) gas, TMI (trimethylindium) gas, nitrogen gas, and dopant gas with carrier gas to sapphire substrate Kami who made it wash, and was made to form them by making a nitride semiconductor form by the MOCVD method. A n type and the nitride

semiconductor of p type conductivity are made to form by switching SiH_4 and Cp_2Mg as dopant gas. The contact layer which is a gallium nitride semiconductor which has n type conductivity as a light emitting device, the cladding layer which is the gallium-aluminum-nitride semiconductors which have p type conductivity, and the contact layer which is gallium nitride which has p type conductivity were made to form. Between the n type contact layer and the p type clad layer, it is about 3 nm in thickness, and the active layer of InGaN used as single quantum well structure is formed. (In addition, gallium nitride is made to form in sapphire substrate Kami at low temperature, and it is considered as the buffer layer.) The p-type semiconductor is made to have heat-treated at more than film-forming back 400 degree C. pn each contact layer surface is exposed to silicon-on-sapphire Kami's nitride semiconductor by the same surface side by etching. Sputtering process was used for each contact layer Kami, and positive/negative each pedestal electrode was made to form in him, respectively. After making a metal thin film form as a translucency electrode all over p type nitride semiconductor Kami, the pedestal electrode is made to have formed in a part of translucency electrode. After pulling a scribe line, external force was made to divide the done semiconductor wafer, and the LED chip which is a semiconductor light emitting element was made to form.

[0036]The copper leadframes containing iron by which it was connected by punching and Stamping by the tie bar, and the cup was formed at the tip of a mount lead on the other hand are formed. The die bonded of the LED chip was carried out into the tip cup of the copper leadframes containing iron which carried out silver plating using the epoxy resin. Wirebonding of each electrode of an LED chip, and the mount lead and inner lead by which the cup was provided was carried out by the gold streak, respectively, and electrical continuity was taken.

[0037]The fluorescent substance carried out the coprecipitation of the solution which dissolved the rare earth element of Y, Gd, and Ce in acid by the stoichiometric ratio with oxalic acid. It mixes with the coprecipitated oxide produced by calcinating this, and an aluminum oxide, and a mixed raw material is obtained. Ammonium fluoride was mixed as flux to this, crucible was stuffed, it calcinated at the temperature of 1400 degreein the air C for 3 hours, and the burned product was obtained. The ball mill of the burned product was carried out underwater, and it was made to form in washing, separation, drying, and the last through a screen.

[0038]25 parts by weight of $(Y_{0.8}Gd_{0.2})_3$aluminum$_5O_{12}$:Ce fluorescent substances and 100 parts by weight of polycarbonate resin which were formed were mixed well, and one piece considered it as the pellet which is a 10 mm^3 degree. This pellet was put in the hopper of the injection molding machine shown in Fig.4. On the other hand, the LED chip electrically connected with the lead terminal is put in a mold, and is made to fix. It injected into the mold by the plunger by injection temperature injection pressure [of 280 degrees C] 800 kgf/cm^2, carrying out heating plasticization and making a pellet agitate. The light emitting diode which covered with the thermoplastics in which the fluorescent substance contained a part of LED chip, mount lead, and inner lead by taking out the lead by which the resin molding was carried out after cooling a mold, and cutting a tie bar, and was formed in the artillery shell type can be obtained. Such 500 light emitting diodes were made to form, and variation was measured. The chromaticity point of the light emitting diode with which the obtained white system can emit light was measured, and it plotted on CIE coordinates. It checked that there was no exterior luminescence unevenness in the light emitting diode of every a piece. It cannot be overemphasized that it can use also in not only an artillery shell type light emitting diode but chip type LED, a segment display, etc.

[0039](Comparative example) After arranging a $_3$aluminum$_5O_{12}$:Ce fluorescent substance in Kapp by casting using the thing mixed in the epoxy resin, the same light emitting diode as the working example 1 was made to form except having carried out curing formation $(Y_{0.8}Gd_{0.2})$. The 500-piece average of a light emitting diode and the light emitting diode of the working example 1 which were formed were compared, and the manufacturing variation of the color temperature was investigated. Compared with the light emitting diode of a comparative example, as for the light emitting diode of the working example, the manufacturing variation of the color temperature became small clearly. The light emitting diode of the comparative example was in the state to which the fluorescent substance became hard at the tip of a molding member.

[0040](Working example 2) As shown in Fig.2, after carrying out injection-moulding sealing of the LED chip 203 periphery with the thermoplastics 201 containing the same fluorescent substance 202 as ****, The light emitting diode 200 was made to form like the working example 1 except having formed outside by using the epoxy resin of translucency as the molding member 208 in cast molding. Thereby, even if the mismatch and burr of a mold occur on the sealing resin surface at the time of injection moulding in addition to above-mentioned hardening, this can be further covered by casting. Therefore, the variation in the lens action of sealing resin and poor soldering by the burr omission at the time of light emitting diode mounting are prevented. It is also possible to reduce the amount of the thermoplastics used of comparatively expensive high translucency and high heat resistance.

[0041](Working example 3) The surface mount type light emitting diode 300 was made to form, as shown in Fig.3. The nitride semiconductor device which has an $In_{0.2}Ga_{0.8}N$ semiconductor whose light emission peak is 475 nm was used for LED chip 303 as a luminous layer. More specifically LED chip 303 to sapphire substrate Kami who made it wash TMG (trimethylgallium) gas, TMI (trimethylindium) gas, nitrogen gas, and dopant gas can be passed with carrier gas, and it can be made to form by making a nitride semiconductor form by the MOCVD method. The layer used as a n type nitride semiconductor or a p type nitride semiconductor is made to form by switching SiH_4 and Cp_2Mg as dopant gas.

[0042]The n type GaN layer which is a nitride semiconductor undoped to silicon-on-sapphire Kami as element structure of an LED chip, The GaN layer which the n type electrode of a Si dope is formed and turns into a n type contact layer, It is considered as the multiple quantum well structure which made five layers of InGaN layers which made one set the n type GaN layer which is a undoped nitride semiconductor, the GaN layer used as the barrier layer which constitutes a luminous layer next, the InGaN layer which constitutes a well layer, and the GaN layer used as a barrier layer, and were inserted into the GaN layer laminate. On the luminous layer, it has composition which made the AlGaN layer and the GaN layer which is p type contact layers by which Mg was doped laminate successively as a p type clad layer by which Mg was doped. (In addition, a GaN layer is made to form in sapphire substrate Kami at low temperature, and it is considered as the buffer layer.) The annealing of the p-type semiconductor is carried out at more than film-forming back 400 degree C.

pn each contact layer surface is exposed to silicon-on-sapphire Kami's nitride semiconductor by the same surface side by etching. Sputtering process was used for each contact layer Kami, and positive/negative each pedestal electrode was made to form in him, respectively. After making a metal thin film form as a translucency electrode all over p type nitride semiconductor Kami, the pedestal electrode is made to have formed in a part of translucency electrode. After pulling a scribe line, external force was made to divide the done semiconductor wafer, and the LED chip which is a semiconductor light emitting element was made to form.

[0043]On the other hand, the metal piece which serves as the pair of lead electrodes 304 and 305 by punching and injection moulding forms the substrate fixed with the insulating resin 309. The die bonded of LED chip 303 was carried out to lead electrode Kami of the copper containing iron who did silver plating using the epoxy resin 306. Wirebonding of each electrode and each lead electrode of an LED chip was carried out by the gold streak 307, respectively, and electrical continuity was taken.

[0044]The fluorescent substance 302 carried out the coprecipitation of the solution which dissolved the rare earth element of Y, Gd, and Ce in acid by the stoichiometric ratio with oxalic acid. It mixes with the coprecipitated oxide produced by calcinating this, and an aluminum oxide, and a mixed raw material is obtained. Ammonium fluoride was mixed as flux to this, crucible was stuffed, it calcinated at the temperature of 1400 degreein the air C for 3 hours, and the burned product was obtained. The ball mill of the burned product was carried out underwater, and it was made to form in washing, separation, drying, and the last through a screen.
[0045]Make 100 parts by weight of triglycidyl isocyanurate, acid anhydride, and hardening accelerator which are 25 parts by weight of $(Y_{0.6}Gd_{0.4})_3$aluminum$_5O_{12}$:Ce fluorescent substances and the nitrogen-containing epoxy resin which were formed agitate at 65 degrees C, they are made to react for 24 hours, and it cools at a room temperature. It becomes the solid stiffened to some extent by this reaction. The taken-out solid is ground and pressed after cooling to a room temperature, and the tablet of a solid state is made to form. In order to make the tablet which made the fluorescent substance contain in translucency resin form, As long as it may make it contain in raw-material translucency resin as mentioned above and homogeneity can be maintained, the tablet which carried out the agitation mix of the translucency resin powder and the fluorescent substance which were stiffened to some extent, and hardened them can also be used.
[0046]Next, the tablet which the mold with which the LED chip made to form by the above and the substrate which took conduction are arranged was made to soften was made to eject, and it was made to harden in 150 degree-C 5 minutes after heating a pot temporarily. Next, secondary hardening was carried out in 150 degree-C 4 hours after picking out the light emitting diode which carried out injection moulding from a mold. The translucency resin 301 which the fluorescent substance contained was able to be made to form in the form projected on the substrate with which an LED chip is arranged.
[0047]Chip type LED made to form has very little dispersion in the light emitting diode formed like ****, and it can be made into white LED with very few irregular colors of each light emitting diode. In order to maintain the resin which made the fluorescent substance contain, it is not necessary to make the side wall used as cavity structure able to form, and a very small white light emitting diode can be made to form. It can be made to form, in order to use thermosetting resin, although it was made to harden to some extent, preventing the damage to the wire etc. to which an LED chip is electrically connected as compared with the case where thermoplastics with comparatively high viscosity is used at the time of injection molding.
[0048]
[Effect of the Invention]The light emitting diode with which the white system which has the fluorescent substance where emitting properties were stabilized can emit light can be made to manufacture with sufficient mass production nature by using the manufacturing method by the present invention. Luminescence dispersion between the light emitting diode first formed at the time of prolonged mass production and the light emitting diode formed in behind can make it very small. Since the luminescence unevenness in the light emitting diode formed comparatively simple can be reduced, mass production nature and the yield can be improved.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]Fig.1 is a typical cross sectional view showing the light emitting diode of the present invention.
[Drawing 2]Fig.2 is a typical cross sectional view showing other light emitting diodes of the present invention.
[Drawing 3]Fig.3 is a typical cross sectional view showing another light emitting diode of the present invention.
[Drawing 4]Fig.4 is a typical cross sectional view of the injection molding machine used for manufacture of the present invention.
[Explanations of letters or numerals]
100, 200, 300 ... Light emitting diode
101, 201, 301 ... Translucency resin containing a fluorescent substance
102, 202, 302 ... Fluorescent substance
103, 203, 303 ... Light emitting device
104, 204 ... Mount lead
105, 205 ... Inner lead
106, 206, 306 ... Mount member to which LED is made to adhere
107, 207, 307 ... Wire
208 ... Molding member
304, 305 ... Lead electrode
309 ... Resin with which between lead electrodes is insulated
400 ... Injection molding machine
401 ... Pellet
402 ... Injection piston
403 ... Screw
404 ... Electrically heated wire
405 ... Mold
406 ... Mount lead by which the light emitting device was mounted

[Translation done.]

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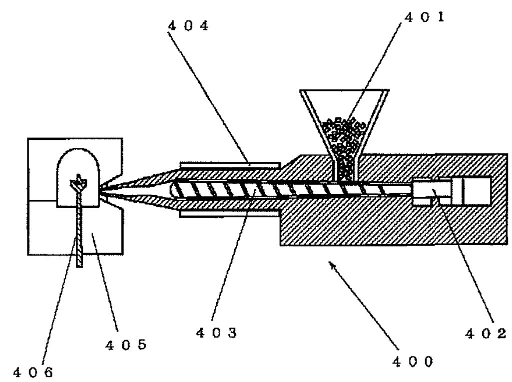
(54)【発明の名称】　発光ダイオード及びその形成方法

(57)【要約】
【課題】発光むら、色むらや形成された発光ダイオード間における発光バラツキが少なく歩留りの高い蛍光物質を利用した発光ダイオードを提供することにある。
【解決手段】発光素子と、発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂とを有し発光素子からの光と蛍光物質からの蛍光の混色光を発光する発光ダイオードである。特に、透光性樹脂は射出成形によって発光素子の少なくとも一部を被覆してなる発光ダイオードである。



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【特許請求の範囲】

【請求項１】　発光素子と、該発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂とを有し前記発光素子からの光と蛍光物質からの蛍光の混色光を発光する発光ダイオードであって、
前記蛍光物質を含有する透光性樹脂は射出成形によって発光素子の少なくとも一部を被覆してなることを特徴とする発光ダイオード。

【請求項２】　発光素子と、該発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂とを有する発光ダイオードの形成方法であって、
前記蛍光物質を含有する透光性樹脂を射出成形して発光素子の少なくとも一部を被覆することを特徴とする発光ダイオードの形成方法。

【請求項３】　発光素子と、該発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂とを有し前記発光素子からの光と蛍光物質からの蛍光の混色光を発光する発光ダイオードの形成方法であって、
前記透光性樹脂は蛍光物質を実質的に均一に含有させた固体状とする工程と、
該固体状となった蛍光物質含有の透光性樹脂を軟化させて発光素子の少なくとも一部を被覆する工程と、
再び前記蛍光物質含有の透光性樹脂を固体状とする工程とを有する発光ダイオードの形成方法。

【請求項４】　前記発光素子の発光層が少なくとも窒化物半導体からなると共に前記蛍光物質がセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体である請求項２又は請求項３に記載の発光ダイオードの形成方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は発光素子から放出される発光波長の少なくとも一部を蛍光物質により変換して放出する発光ダイオードに係わり、特に、発光むら、色むらや形成された発光ダイオード間における発光バラツキが少なく歩留りの高い発光ダイオードに関するものである。

【０００２】

【従来の技術】半導体発光素子は、小型で効率よく鮮やかな色の発光をする。また、半導体素子であるため球切れがない。駆動特性が優れ、振動やＯＮ／ＯＦＦ点灯の繰り返しに強いという特徴を有する。そのため、各種インジケータや種々の光源として利用されている。しかしながら、このような発光素子は単色性のピーク波長を有するが故に白色系（白、ピンクや電球色など）の発光のみを得る場合においても、２種類以上の発光素子を利用せざるを得なかった。また、種々の発光色を簡単に得ることはできなかった。

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【０００３】単色性のピーク波長を発するＬＥＤチップと蛍光物質を利用して種々の発光色を発光させる発光ダイオードとして、特開平７－９９３４５号公報などに記載されたものが知られている。これらの発光ダイオードは、発光チップの発光を発光観測面側に反射するカップの底部に発光チップを積載させると共にカップ内部に充填された樹脂と、全体を覆った樹脂から構成することができる。内部に充填された樹脂中には発光チップからの光を吸収し、波長変換する蛍光物質を含有させてある。

【０００４】蛍光物質が含有された樹脂は、液状のエポキシ樹脂などを発光素子が搭載されたカップ上に滴下注入し、加熱硬化させ色変換部材とさせる。カップ内部以外の樹脂は液状のエポキシ樹脂などを注型したキャスティングケース内に、色変換部材及び発光チップが形成されたフレーム部材先端を浸漬配置し、これをオーブンに入れ加熱硬化させることにより形成する。これにより、発光チップからの発光波長を蛍光物質によって波長変換した発光ダイオードとすることができる。例えば、ＬＥＤチップからの青色系の光と、その青色系の光を吸収し補色関係にある黄色系を発光する蛍光体からの光との混色により白色が発光可能な発光ダイオードとすることができる。

【０００５】このような発光ダイオードを用いて、所望の白色系などを発光させるためには、それぞれの光を極めて精度良く発光させ混色調整させる必要がある。ＬＥＤチップからの光は、その半導体及び駆動電流などにより調節させることができる。一方、蛍光物質からの波長変換された光も蛍光物質の組成や粒径を制御することによってある程度調整することができる。

【０００６】

【発明が解決しようとする課題】しかし、蛍光物質自体には密着力がない、或いは弱いため発光素子上に配置固定させるためには、種々の樹脂中など発光素子及び蛍光物質それぞれの光が放出可能な密着性を有するバインダー中に含有させる必要がある。このようなバインダー中に含有された蛍光物質は、その蛍光物質の含有量や分布などによってＬＥＤチップから放出された光量及び蛍光物質から放出された光量が大きく左右される。これらが制御できず、また発光素子から放出される可視光と蛍光物質から放出される光が可視光の混色によって色表現させる場合には、それぞれの可視光量の違いが大きな問題となる。特に、白色系は人間の目が僅かな色温度差でも識別することができるため大きな問題となる。したがって、本発明は上記問題点を解決し、極めて精度良く蛍光物質の含有量及び分布を均一とさせ発光特性の優れた、歩留りの高い発光ダイオードを提供することにある。

【０００７】

【課題を解決するための手段】本発明者は種々実験の結果、蛍光物質を利用した発光ダイオードにおいて、発光

ダイオード間のバラツキや発光ダイオードの色むらや発光むらは、蛍光物質の分布に大きく起因していること及び特定の形成方法により制御しうることを見出し本発明を成すに至った。

【０００８】即ち、蛍光物質が含有された液状の透光性樹脂を発光素子が配置された上に注入して形成させる場合、注型での充填性を考慮し、粘度が５００～１０００ｃｐｓ程度の低粘度のものが用いられる。蛍光物質と樹脂との比重が大きく異なるため、このような透光性樹脂中に蛍光物質を混合すると、両者は容易に分離する。したがって、軽い有機蛍光物質などを利用した場合は浮遊し、重い無機蛍光物質などを利用した場合は沈降する傾向にある。このような分離は蛍光物質の分散不均一を生ずる。

【０００９】特に、バッチ式に樹脂と蛍光物質を混合した混合体を少量ずつ注型していく方法を繰り返して製造する場合、混合体の樹脂と蛍光物質の分離は時間と共に進行する。したがって、混合直後に注型して製造された発光ダイオードと、混合後しばらく後に注型して製造された発光ダイオードでは、蛍光物質の含有量が異なってしまう傾向にある。

【００１０】また、注型が完了した発光ダイオードを加熱硬化させる時、樹脂が固体化するまでの間、温度上昇に伴い粘度が低下する。そのため、キャスティングケース内でも樹脂と蛍光物質の比重差による分離が発生し易い傾向にある。特に、発光素子からの可視発光と蛍光物質からの可視蛍光との混色光を発光させる発光ダイオードにおいては、蛍光物質の含有量変化及び封止樹脂内での分布不均一がすべて発光色の色温度変化として顕著に現れる。このような問題を以下の本発明によって解決することができる。即ち、本発明は、発光素子と、発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂を有し発光素子からの光と蛍光物質からの蛍光の混色光を発光する発光ダイオードである。特に、透光性樹脂は射出成形によって発光素子の少なくとも一部を被覆してなる。これによって制御性よく均一発光可能な発光ダイオードとすることができる。

【００１１】また、本発明の請求項２に記載の発光ダイオードの形成方法は、発光素子からの発光波長の少なくとも一部を吸収して蛍光を発する蛍光物質を含有した透光性樹脂を発光素子上に射出成形で形成する発光ダイオードの形成方法である。これにより、形成された発光ダイオードの封止樹脂中に蛍光物質を極めて均一に混合させ光特性の安定した発光ダイオードが得られるものである。

【００１２】本発明の請求項３に記載の発光ダイオードの形成方法は、発光素子と、発光素子からの発光波長の少なくとも一部を吸収し蛍光を発する蛍光物質を含有する透光性樹脂とを有し発光素子からの光と蛍光物質からの蛍光の混色光を発光する発光ダイオードの形成方法である。特に、透光性樹脂は蛍光物質を実質的に均一に含有させた固体状とする工程と、固体状となった蛍光物質含有の透光性樹脂を軟化させて発光素子の少なくとも一部を被覆する工程と、再び前記蛍光物質含有の透光性樹脂を固体状とする工程とを有する発光ダイオードの形成方法である。

【００１３】また、本発明の請求項４に記載の発光ダイオードの形成方法は、発光素子の発光層が少なくとも窒化物半導体からなると共に蛍光物質がセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体（以下、ＹＡＧ蛍光体と呼ぶこともある。）である。これにより、形成された発光ダイオード間のバラツキがより少なく発光むらや色むらの少ない白色光が発光可能な発光ダイオードを形成させることができる。

【００１４】

【発明の実施の形態】本発明の実施態様例による発光ダイオードとして図１に、白色発光可能な発光ダイオード１００の模式的断面図を示してある。銅あるいは鉄系合金材の表面に銀あるいは金等のメッキ処理が施されたマウント・リード１０４の先端にＬＥＤチップを搭載するカップ上部を有する。搭載されたＬＥＤチップは単体では青色系の可視光を発光する発光素子１０３であり、マウント部材１０６となるエポキシ樹脂によりマウント固着されている。発光素子１０３の各電極は、金等よりなるワイヤ１０７でマウント・リード１０４及びインナー・リード１０５とワイヤボンド結合している。耐熱性に優れた透光性樹脂１０１としてノルボネン系樹脂、ポリメチルペンテン樹脂（ＴＰＸ）、非晶質ナイロン樹脂などの熱可塑性樹脂や脂環式エポキシ樹脂や含窒素エポキシ樹脂等の熱硬化性樹脂によって封止してある。透光性樹脂中には、青色光を照射すると黄色の蛍光を発するＣｅで付活されたＹＡＧ蛍光体１０２を約５質量％混合してある。

【００１５】発光ダイオードは、リードフレームにＬＥＤチップをマウント、ワイヤボンドしたものを成形型にインサートし、１個が数十mm^3程度のペレット状の樹脂とＹＡＧ蛍光体をホッパに撹拌しながら収容したもの、或いは予め樹脂ペレット内にＹＡＧ蛍光体を混ぜ込んだものをホッパ内に収容した射出成形機で、射出成形し封止する。射出成型は樹脂を成型機のスクリュー内で数秒程度の短時間で加熱溶融、撹拌圧送し、型内に樹脂を注入し、型内に注入された樹脂は速やかに冷却され、数十秒で固化する。

【００１６】本発明で透光性樹脂は、成型前状態において固体状とできる。成型機投入前に均一に樹脂ペレットと蛍光物質とを混合しておけば、液体のように樹脂中の蛍光物質が自由に沈降あるいは浮遊することはない。そのため、蛍光物質の混合状態は型内に投入前の状態まま保持される。また、成形時に樹脂が溶融し液体で存在す

る期間は数分から数十秒と、注型成形により熱硬化形成する方法の数時間と比較して極めて短い。また、射出される際にスクリューで加圧攪拌される場合、樹脂中での蛍光物質の分布はより均一にすることができる。さらに、固化までの時間も極めて短く樹脂と蛍光物質との分離もほとんど発生しない。

【００１７】すなわち、成形前及び成形後固化までの間に樹脂と蛍光物質との分離が極めて発生し難い。これにより本発明の発光ダイオードでは、樹脂と蛍光物質の比重差によらず樹脂中に均一分散させることができる。そのため、発光ダイオード内の蛍光物質の分布均一だけでなく、製造ロット毎の蛍光物質の含有量バラツキも極めて少ない。

【００１８】特にＹＡＧ：Ｃｅ蛍光体を蛍光物質として含有した白色発光が可能な発光ダイオードとした場合、樹脂に較べ比重の大きいＹＡＧ：Ｃｅ蛍光体でも常時極めて均一な分布のものができる。そのため色温度の均一な発光ダイオードが安定して形成し得る。以下、本発明に用いられる各構成について詳述する。

【００１９】（射出成形機４００）本発明に用いられる射出成形機４００としては、図４の如き蛍光物質含有の透光性樹脂を加熱溶融させプランジャー４０２でノズルを通して金型４０５内に射出し成形させられるために好適に用いられる。したがって、射出成型機は予め蛍光物質が一定量含有された透光性樹脂のペレット４０１を軟化溶融させ射出するためのプランジャー、プランジャーで押し出される融解樹脂を金型内に導くノズル及び成型品の形を与える金型から主として構成することができる。特に、発光ダイオードが発光素子からの可視光と、この可視光によって励起されると共に発光する蛍光物質との混色発光させる場合、混合分布量がごく微少量でも異なるとその発光色の変動が大きくなる。そのため、蛍光物質が含有された透光性樹脂を予備可塑化装置などを利用して攪拌溶融させることが好ましい。このような攪拌は、透光性樹脂中に含有される蛍光物質の密度が変化しない限り連続的、間欠的になど種々行うことができる。また、攪拌回転数は攪拌部となるスクリュー４０３の大きさ、蛍光物質の粒径や形状、バインダーの粘度、材質などによって種々選択させることができる。

【００２０】（透光性樹脂１０１）本発明に用いられる透光性樹脂は蛍光物質を内部に含有させ射出により一定の形状をとることができる樹脂である。具体的には、ノルボネン樹脂、ポリメチルペンテン樹脂、非晶質ナイロン樹脂、ポリアリレートやポリカーボネート樹脂など透光性がありかつ耐熱性に優れた熱可塑性樹脂、ポリアミドや酢酸ビニル等の１００℃から２６０℃程度の比較的低温、1から２５Ｋｇｆ／ｃｍ^{2}程度の比較的低圧にていわゆるホットメルト成形と称される射出成形が可能でかつ透光性を有する熱可塑性樹脂及び脂環式エポキシ樹脂、含窒素エポキシ樹脂等の熱硬化性樹脂が好適に挙げられる。これらの樹脂中に蛍光物質を溶融分散させ一定の大きさに形成させることで射出形成の軟化溶融材料となるペレットなどとすることができる。これらの透光性樹脂には所望の波長をカットする着色剤、所望の光を拡散させる拡散材、樹脂の耐光性を高める紫外線吸収剤、酸化防止剤や硬化促進剤など種々の添加剤を含有させることができる。

【００２１】（蛍光物質１０２）本発明に用いられる蛍光物質としては、発光素子から発光された電磁波で励起されて蛍光を発する蛍光物質をいう。蛍光物質は一般に発光波長よりも励起波長が短波長の方が効率が良いため、発光素子からの発光波長よりも長波長の蛍光を発する蛍光体を用いることが好ましい。具体的蛍光物質として青色の発光素子との混色により白色を発光させるためには、セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体、ペリレン系誘導体、銅で付活されたセレン化亜鉛など種々のものが挙げられる。特に、イットリウム・アルミニウム・ガーネット系蛍光体は、発光素子に窒化物半導体を用いた場合、耐光性や効率などの観点から特に好ましい。

【００２２】セリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体は、ガーネット構造のため、熱、光及び水分に強く、励起スペクトルのピークが４５０ｎｍ付近にさせることができる。また、発光ピークも５３０ｎｍ付近にあり７００ｎｍまで裾を引くブロードな発光スペクトルを持たすことができる。なお、本発明においてセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体とは、最も広義に解釈するものとして$Y_3Al_5O_{12}$：Ｃｅのイットリウム（Ｙ）の代わりにＬｕ、Ｓｃ、Ｌａ、Ｇｄ、Ｓｍから選択される少なくとも一種と置き換えることができるものである。また、アルミニウム（Ａｌ）の代わりにＧａ、Ｉｎ、Ｂ、Ｔｌから選択される少なくとも一種と置き換えることができるものである。組成を変化させることで発光色を連続的に調節することが可能である。即ち、長波長側の強度がＧｄの組成比で連続的に変えられるなど窒化物半導体の青色系発光を白色系発光に変換するための理想条件を備えている。同様に、Ｌｕ、Ｌｃ、ＳｃやＳｍなどを加えて所望の特性を得るようにしても良い。

【００２３】このような蛍光物質は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍ、Ｌａ、Ａｌ及びＧａの原料として酸化物、又は高温で容易に酸化物になる化合物を使用し、それらを化学量論比で十分に混合して原料を得る。又は、Ｙ、Ｇｄ、Ｃｅ、Ｓｍ、Ｌａの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈したものを焼成して得られる共沈酸化物と、酸化アルミニウム、酸化ガリウムとを混合して混合原料を得る。これにフラックスとしてフッ化アンモニウム等のフッ化物を適量混合して坩堝に詰め、空気中１３５０～１４５０°Ｃの温度範囲で２～５時間焼成して焼成品を得、次に焼成品を水中でボールミルし

て、洗浄、分離、乾燥、最後に篩を通すことで得ることができる。

【００２４】本発明の発光ダイオードにおいて、このような蛍光物質を２種類以上混合させてもよい。具体的には、Ａｌ、Ｇａ、Ｙ及びＧｄ、ＬａやＳｍの含有量が異なる２種類以上のセリウムで付活されたイットリウム・アルミニウム・ガーネット系蛍光体を混合させてＲＧＢの波長成分を増やすことなどができる。このような場合、異なる蛍光物質間の比重が異なっていても量産性よく発光特性の均一な発光ダイオードを形成することができる。

【００２５】（発光素子１０３、２０３）本発明に用いられる発光素子１０３とは、蛍光物質を励起可能な発光波長を発光できる発光層を有する半導体発光素子である。このような半導体発光素子としてＺｎＳｅやＧａＮなど種々の半導体を挙げることができるが、蛍光物質を効率良く励起できる短波長が発光可能な窒化物半導体（$In_X Al_Y Ga_{1-X-Y} N$、0≦Ｘ、0≦Ｙ、Ｘ＋Ｙ≦１）が好適に挙げられる。半導体の構造としては、ＭＩＳ接合、ＰＩＮ接合やｐｎ接合などを有するホモ構造、ヘテロ構造あるいはダブルヘテロ構成のものが挙げられる。半導体層の材料やその混晶度によって発光波長を種々選択することができる。また、半導体活性層を量子効果が生ずる薄膜に形成させた単一量子井戸構造や多重量子井戸構造とすることもできる。

【００２６】窒化物半導体を使用した場合、半導体用基板にはサファイヤ、スピネル、ＳｉＣ、Ｓｉ、ＺｎＯ等の材料が好適に用いられる。結晶性の良い窒化物半導体を量産性よく形成させるためにはサファイヤ基板を用いることが好ましい。このサファイヤ基板上にＭＯＣＶＤ法などを用いて窒化物半導体を形成させることができる。サファイア基板上にＧａＮ、ＡｌＮ、ＧａＡＩＮ等のバッファー層を形成しその上にｐｎ接合を有する窒化物半導体を形成させる。

【００２７】窒化物半導体を使用したｐｎ接合を有する発光素子例として、バッファ層上に、ｎ型窒化ガリウムで形成した第１のコンタクト層、ｎ型窒化アルミニウム・ガリウムで形成させた第１のクラッド層、窒化インジウム・ガリウムで形成した活性層、ｐ型窒化アルミニウム・ガリウムで形成した第２のクラッド層、ｐ型窒化ガリウムで形成した第２のコンタクト層を順に積層させたダブルヘテロ構成などが挙げられる。

【００２８】窒化物半導体は、不純物をドープしない状態でｎ型導電性を示す。発光効率を向上させるなど所望のｎ型窒化物半導体を形成させる場合は、ｎ型ドーパントとしてＳｉ、Ｇｅ、Ｓｅ、Ｔｅ、Ｃ等を適宜導入することが好ましい。一方、ｐ型窒化物半導体を形成させる場合は、ｐ型ドーパントであるＺｎ、Ｍｇ、Ｂｅ、Ｃａ、Ｓｒ、Ｂａ等をドープさせる。窒化物半導体は、ｐ型ドーパントをドープしただけではｐ型化しにくいためｐ型ドーパント導入後に、炉による加熱やプラズマ照射等により加熱処理することで低抵抗化させることが好ましい。電極形成後、半導体ウエハーからチップ状にカットさせることで窒化物半導体からなる発光素子を形成させることができる。

【００２９】本発明の発光ダイオードにおいて白色系を発光させる場合は、蛍光物質からの発光波長との補色関係や透光性樹脂の劣化等を考慮して発光素子の発光波長は４００ｎｍ以上５３０ｎｍ以下が好ましく、４２０ｎｍ以上４９０ｎｍ以下がより好ましい。発光素子と蛍光物質との励起、発光効率をそれぞれより向上させるためには、４５０ｎｍ以上４７５ｎｍ以下がさらに好ましい。なお、４００ｎｍより短い紫外域の波長を利用できることは言うまでもない。

【００３０】（マウント・リード１０４、２０４）マウント・リード１０４としては、発光素子を配置させるものであり、ダイボンド機器などで積載するのに十分な大きさがあれば良い。また、発光素子を複数設置しマウント・リードを発光素子の共通電極として利用する場合においては、十分な電気伝導性とボンディングワイヤ等との接続性が求められる。また、マウント・リード上のカップ内に発光素子を配置すると共に蛍光体を内部に充填させる場合は、近接して配置させた別の発光ダイオードからの光により疑似点灯することを防止することができる。

【００３１】発光素子とマウント・リードのカップとの接着はマウント部材１０６として熱硬化性樹脂などによって行うことができる。具体的には、エポキシ樹脂、アクリル樹脂、シリコン樹脂やイミド樹脂などが挙げられる。また、フリップチップ型の発光素子によりマウント・リードと接着させると共に電気的に接続させるためにはＡｇペースト、Ｃｕペースト、カーボンペースト、金属バンプや金属酸化物が含有された樹脂等を用いることができる。また、マウント・リードの具体的な電気抵抗としては３００μΩ・ｃｍ以下が好ましく、より好ましくは、３μΩ・ｃｍ以下である。また、マウント・リード上に複数の発光素子を積載する場合は、発光素子からの発熱量が多くなるため熱伝導度がよいことが求められる。具体的には、０．０１ｃａｌ／ｃｍ^2／ｃｍ／℃以上が好ましくより好ましくは０．５ｃａｌ／ｃｍ^2／ｃｍ／℃以上である。これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅、メタライズパターン付きセラミック等が挙げられる。

【００３２】（インナー・リード１０５、２０５）インナー・リードとしては、マウント・リード上に配置された発光素子と導電性ワイヤなどを介して電気的に接続を図るものである。インナー・リードは、ボンディングワイヤ等との接続性及び電気伝導性が良いことが求められる。具体的な電気抵抗としては、３００μΩ・ｃｍ以下が好ましく、より好ましくは３μΩ・ｃｍ以下である。

これらの条件を満たす材料としては、鉄、銅、鉄入り銅、錫入り銅及び銅、金、銀をメッキしたアルミニウム、鉄、銅等が挙げられる。

【００３３】（ワイヤ１０７、２０７）ワイヤ１０７としては、発光素子の電極とのオーミック性、密着性、電気伝導性及び熱伝導性がよいものが求められる。熱伝導度としては０．０１ｃａｌ／ｃｍ^2／ｃｍ／℃以上が好ましく、より好ましくは０．５ｃａｌ／ｃｍ^2／ｃｍ／℃以上である。また、作業性などを考慮してワイヤの直径は、好ましくは、Φ１０μｍ以上、Φ４５μｍ以下である。このようなワイヤとして具体的には、金、銅、白金、アルミニウム等の金属及びそれらの合金を用いたワイヤが挙げられる。このようなワイヤは、各発光素子の電極と、インナー・リード及びマウント・リードなどとをワイヤボンディング機器によって容易に接続させることができる。

【００３４】（モールド部材２０８）モールド部材２０８は、発光ダイオードの使用用途に応じて発光素子１０３、ワイヤ１０７、蛍光物質１０２などを外部から保護するために設けることができる。モールド部材は、一般には樹脂を用いて形成させることができる。また、蛍光体を含有させることによって視野角を増やすことができるが、樹脂モールドに拡散剤を含有させることによって発光素子からの指向性を緩和させ視野角をさらに増やすことができる。更にまた、モールド部材を所望の形状にすることによって発光素子からの発光を集束させたり拡散させたりするレンズ効果を持たせることができる。したがって、モールド部材は複数積層した構造でもよい。具体的には、凸レンズ形状、凹レンズ形状さらには、発光観測面から見て楕円形状やそれらを複数組み合わせた物である。モールド部材の具体的材料としては、主としてエポキシ樹脂、ユリア樹脂、シリコーン樹脂などの耐候性に優れた透明樹脂や硝子などが好適に用いられる。また、拡散剤としては、チタン酸バリウム、酸化チタン、酸化アルミニウム、酸化珪素等が好適に用いられる。また、屈折率差を考慮してモールド部材と結着剤とを同じ材質のものを用いて形成させても良い。以下、本発明の具体的実施例について詳述するがこれのみに限定されないことは言うまでもない。

【００３５】

【実施例】（実施例１）ＬＥＤチップは、発光層として発光ピークが４５０ｎｍの$In_{0.2}Ga_{0.8}N$半導体を用いた。ＬＥＤチップは、洗浄させたサファイヤ基板上にＴＭＧ（トリメチルガリウム）ガス、ＴＭＩ（トリメチルインジウム）ガス、窒素ガス及びドーパントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化物半導体を成膜させることにより形成させた。ドーパントガスとしてSiH_4とCp_2Mgとを切り替えることによってｎ型やｐ型導電性の窒化物半導体を形成させる。発光素子としてはｎ型導電性を有する窒化ガリウム半導体であるコンタクト層と、ｐ型導電性を有する窒化アルミニウムガリウム半導体であるクラッド層、ｐ型導電性を有する窒化ガリウムであるコンタクト層を形成させた。ｎ型コンタクト層とｐ型クラッド層との間に厚さ約３ｎｍであり、単一量子井戸構造となるＩｎＧａＮの活性層を形成してある。（なお、サファイヤ基板上には低温で窒化ガリウムを形成させバッファ層とさせてある。また、ｐ型半導体は、成膜後４００℃以上で熱処理させてある。）エッチングによりサファイア基板上の窒化物半導体に同一面側で、ｐｎ各コンタクト層表面を露出させる。各コンタクト層上に、スパッタリング法を用いて正負各台座電極をそれぞれ形成させた。なお、ｐ型窒化物半導体上の全面には金属薄膜を透光性電極として形成させた後に、透光性電極の一部に台座電極を形成させてある。出来上がった半導体ウエハーをスクライブラインを引いた後、外力により分割させ半導体発光素子であるＬＥＤチップを形成させた。

【００３６】一方、打ち抜き及びスタンピングによりタイバーで接続されマウント・リード先端にカップが形成された鉄入り銅製リードフレームを形成する。ＬＥＤチップはエポキシ樹脂を用いて銀メッキした鉄入り銅製リードフレームの先端カップ内にダイボンドした。ＬＥＤチップの各電極と、カップが設けられたマウント・リードやインナー・リードとをそれぞれ金線でワイヤボンディングし電気的導通を取った。

【００３７】蛍光物質は、Ｙ、Ｇｄ、Ｃｅの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウムと混合して混合原料を得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中１４００°Ｃの温度で３時間焼成して焼成品を得た。焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通して形成させた。

【００３８】形成された$(Y_{0.8}Gd_{0.2})_3Al_5O_{12}$：Ｃｅ蛍光物質２５重量部、ポリカーボネート樹脂１００重量部をよく混合して１個が十ｍｍ^{3}程度のペレットとさせた。このペレットを図４に示す射出成型機のホッパ中に入れた。他方、リード端子と電気的に接続されたＬＥＤチップを金型中に入れ固定させる。ペレットを加熱可塑化させ攪拌させながらプランジャーにより射出温度２８０℃射出圧力８００ｋｇｆ／ｃｍ^{2}で金型中に注入した。金型を冷却後、樹脂モールドされたリードを取り出しタイバーを切断することでＬＥＤチップ、マウント・リード及びインナー・リードの一部を蛍光物質が含有された熱可塑性樹脂で被覆して砲弾型に形成された発光ダイオードを得ることができる。こうした発光ダイオードを５００個形成させバラツキを測定した。得られた白色系が発光可能な発光ダイオードの色度点を測定しＣＩＥ座標上にプロットした。また、一個ずつの発光ダイオードにおいて外観上の発光むらがないことを確認した。

なお、砲弾型発光ダイオードだけではなく、チップタイプＬＥＤやセグメントディスプレイなどにおいても利用することができることは言うまでもない。
【００３９】（比較例）$(Y_{0.8}\ Gd_{0.2})_3Al_5O_{12}$：Ｃｅ蛍光物質をエポキシ樹脂中に混合したものを用いて注型によりカップ内に配置させた後に、硬化形成した以外は実施例１と同様の発光ダイオードを形成させた。形成された発光ダイオードの５００個平均と実施例１の発光ダイオードとを比較して色温度の製造バラツキを調べた。比較例の発光ダイオードに較べ実施例の発光ダイオードは、色温度の製造バラツキが明らかに小さくなった。なお、比較例の発光ダイオードは、モールド部材の先端に蛍光物質が固まった状態であった。
【００４０】（実施例２）図２に示すようにＬＥＤチップ２０３周辺を上述と同様の蛍光物質２０２を含有した熱可塑性樹脂２０１で射出成形封止した後、注型成形にて透光性のエポキシ樹脂をモールド部材２０８として外側に形成した以外は実施例１と同様にして発光ダイオード２００を形成させた。これにより、上述の硬化に加え、射出成形時に封止樹脂表面に型のミスマッチやバリが発生しても、これをさらに注型で覆うことができる。そのため、封止樹脂のレンズ作用のバラツキや発光ダイオード実装時のバリ脱落によるはんだ付け不良等が防止される。また、比較的高価な高透光性かつ高耐熱性の熱可塑性樹脂の使用量を減らすことも可能である。
【００４１】（実施例３）図３に示すように表面実装型の発光ダイオード３００を形成させた。ＬＥＤチップ３０３は、発光層として発光ピークが４７５ｎｍの$In_{0.2}\ Ga_{0.8}\ N$半導体を有する窒化物半導体素子を用いた。より具体的にはＬＥＤチップ３０３は、洗浄させたサファイヤ基板上にＴＭＧ（トリメチルガリウム）ガス、ＴＭＩ（トリメチルインジウム）ガス、窒素ガス及びドーパントガスをキャリアガスと共に流し、ＭＯＣＶＤ法で窒化物半導体を成膜させることにより形成させることができる。ドーパントガスとしてSiH_4とCp_2Mgを切り替えることによってｎ型窒化物半導体やｐ型窒化物半導体となる層を形成させる。
【００４２】ＬＥＤチップの素子構造としてはサファイア基板上に、アンドープの窒化物半導体であるｎ型ＧａＮ層、Ｓｉドープのｎ型電極が形成されｎ型コンタクト層となるＧａＮ層、アンドープの窒化物半導体であるｎ型ＧａＮ層、次に発光層を構成するバリア層となるＧａＮ層、井戸層を構成するＩｎＧａＮ層、バリア層となるＧａＮ層を１セットとしＧａＮ層に挟まれたＩｎＧａＮ層を５層積層させた多重量子井戸構造としてある。発光層上にはＭｇがドープされたｐ型クラッド層としてＡｌＧａＮ層、Ｍｇがドープされたｐ型コンタクト層であるＧａＮ層を順次積層させた構成としてある。（なお、サファイヤ基板上には低温でＧａＮ層を形成させバッファ層とさせてある。また、ｐ型半導体は、成膜後４００℃以上でアニールさせてある。）
エッチングによりサファイア基板上の窒化物半導体に同一面側で、ｐｎ各コンタクト層表面を露出させる。各コンタクト層上に、スパッタリング法を用いて正負各台座電極をそれぞれ形成させた。なお、ｐ型窒化物半導体上の全面には金属薄膜を透光性電極として形成させた後に、透光性電極の一部に台座電極を形成させてある。出来上がった半導体ウエハーをスクライブラインを引いた後、外力により分割させ半導体発光素子であるＬＥＤチップを形成させた。
【００４３】一方、打ち抜き及び射出成形により一対のリード電極３０４、３０５となる金属片が絶縁性樹脂３０９によって固定された基板を形成する。ＬＥＤチップ３０３はエポキシ樹脂３０６を用いて銀メッキした鉄入り銅製のリード電極上にダイボンドした。ＬＥＤチップの各電極と、各リード電極とをそれぞれ金線３０７でワイヤボンディングし電気的導通を取った。
【００４４】蛍光物質３０２は、Ｙ、Ｇｄ、Ｃｅの希土類元素を化学量論比で酸に溶解した溶解液を蓚酸で共沈させた。これを焼成して得られる共沈酸化物と、酸化アルミニウムと混合して混合原料を得る。これにフラックスとしてフッ化アンモニウムを混合して坩堝に詰め、空気中１４００°Ｃの温度で３時間焼成して焼成品を得た。焼成品を水中でボールミルして、洗浄、分離、乾燥、最後に篩を通して形成させた。
【００４５】形成された$(Y_{0.6}\ Gd_{0.4})_3Al_5O_{12}$：Ｃｅ蛍光物質２５重量部、含窒素エポキシ樹脂であるトリグリシジルイソシアヌレート１００重量部と酸無水物及び硬化促進剤を６５℃で撹拌させ２４時間反応させ室温で冷却する。この反応によりある程度硬化させた固体となる。室温に冷却後、取り出した固体を粉砕しプレスして固体状のタブレットを形成させる。なお、蛍光物質を透光性樹脂中に含有させたタブレットを形成させるためには、上述のように原材料透光性樹脂中に含有させても良いし、均一性を保てる限りにおいて、ある程度硬化させた透光性樹脂粉体と蛍光物質とを混合撹拌させ固めたタブレットを利用することもできる。
【００４６】次にポットを加熱後、上記で形成させたＬＥＤチップと導通を取った基板が配置された金型に軟化させたタブレットを射出させ１５０℃５分で一時硬化させた。次に、金型から射出成形させた発光ダイオードを取り出した後、１５０℃４時間で二次硬化させた。蛍光物質が含有された透光性樹脂３０１は、ＬＥＤチップが配置された基板上に突出した形状で形成させることができた。
【００４７】形成させたチップタイプＬＥＤは上述と同様に形成された発光ダイオードのばらつきが極めて少ないと共に各発光ダイオードの色むらが極めて少ない白色ＬＥＤとすることができる。また、蛍光物質を含有させた樹脂を維持させるためにキャビティー構造となる側壁

を形成させる必要もなく極めて小型な白色発光ダイオードを形成させることができる。さらに、ある程度硬化させたとはいえ熱硬化性樹脂を用いるため、射出成型時に比較的粘度が高い熱可塑性樹脂を用いた場合と比較してＬＥＤチップを電気的に接続させるワイヤなどの損傷を防ぎつつ形成させることができる。

【００４８】

【発明の効果】本発明による製造方法を用いることによって、発光特性が安定した蛍光物質を有する白色系が発光可能な発光ダイオードを量産性良く製造させることができる。また、長時間量産時においても最初に形成された発光ダイオードと、後に形成された発光ダイオード間の発光ばらつきが極めて小さくさせることができる。さらに、比較的簡便に形成された発光ダイオード内における発光むらを低減させることができるため量産性と歩留りを向上させることができる。

【図面の簡単な説明】

【図１】　図１は本発明の発光ダイオードを示す模式的断面図である。

【図２】　図２は本発明の他の発光ダイオードを示す模式的断面図である。

【図３】　図３は本発明の別の発光ダイオードを示す模式的断面図である。　＊

＊【図４】　図４は本発明の製造に用いられる射出成型機の模式的断面図である。

【符号の説明】

１００、２００、３００・・・発光ダイオード

１０１、２０１、３０１・・・蛍光物質を含有する透光性樹脂

１０２、２０２、３０２・・・蛍光物質

１０３、２０３、３０３・・・発光素子

１０４、２０４・・・マウント・リード

１０５、２０５・・・インナー・リード

１０６、２０６、３０６・・・ＬＥＤを接着させるマウント部材

１０７、２０７、３０７・・・ワイヤ

２０８・・・モールド部材

３０４、３０５・・・リード電極

３０９・・・リード電極間を絶縁する樹脂

４００・・・射出成形機

４０１・・・ペレット

４０２・・・射出ピストン

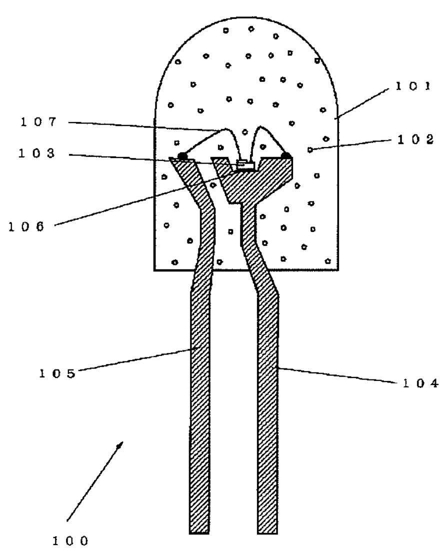
４０３・・・スクリュー

４０４・・・電熱線

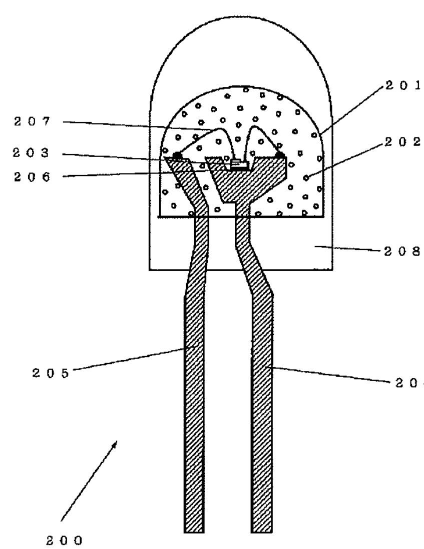
４０５・・・金型

４０６・・・発光素子がマウントされたマウントリード

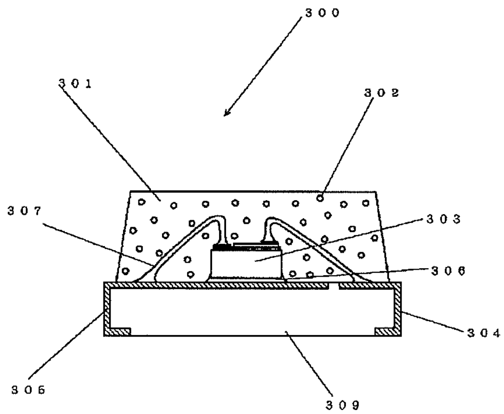
【図１】



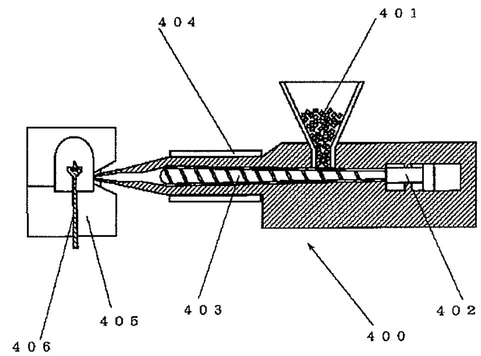
【図２】



【図3】



【図4】



(1,500円)

実用新案登録願（　　）

昭和 46年 9月 13日

特許庁長官殿

1 考案の名称

コタイハッコウソウチ
固体発光装置

2 考案者

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5 添付書類の目録

(1)	明細書	1通
(2)	図面	1通
(3)	委任状	1通
(4)	願書副本	1通

特許庁 46.9.16

48-39866-01

明細書

1、考案の名称

固体発光装置

2、実用新案登録請求の範囲

固体発光素子の上面に透明樹脂あるいはガラスレンズ体を載架してなる固体発光装置において、上記レンズ体内部に少くとも上記レンズ構成体よりも屈折率が高く、かつ粒径が10μ以下の光散乱体を含有することを特徴とする固体発光装置。

3、考案の詳細な説明

本考案はⅢ－Ⅴ化合物のpn接合を利用した固体発光装置、特に素子上面に載架されるレンズ体の構成に関するもので、見掛上の発光面積を大きくし、かつ指向性を少なくすることを目的とする。

GaAs, GaP, あるいは$GaAs_{1-x}P_x$など、Ⅲ－Ⅴ化合物のpn接合を利用したいわゆる注入型発光素子は固体表示ランプあるいは数字文字表示装置として利用される。前者はタングステン線等を用いた小型白熱ランプに対し、長寿命，低電力，高信頼性などの特長を有している。上記注入型発光素子

として利用される材料にはⅢ－Ⅴ族およびⅡ－Ⅵ族化合物が大部分を占め、とりわけ$GaAs_{1-x}P_x$，$Ga_{1-x}Al_xAs$，$Ga_{1-x}In_x$，GaP等のⅢ－Ⅴ族化合物が可視発光を実現するものとして利用される。しかしこれらのいわゆる化合物半導体は材料としても高価である。

また発光効率を向上さすためその上にエピタキシャル成長等を施した基板はSi，Geに比較して極めて高価となり固体表示ランプのコストに占める割合は非常に大きい。従って固体表示ランプに使用される結晶の大きさは一般に0.4～0.7㎜角程度が利用され、従来のタングステン線小型白熱ランプに比べればその発光面積は非常に小さい。従ってたとえばその上にエポキシ等の樹脂レンズを装架して見掛の発光面積を大きくする方法もとられる。さらに他の問題点としてこれらの化合物と空気との屈折率の差が大きいために（例えばGaAs，n＝3.6）、内面反射による結晶内部での光の損失が大きくなり、外部発光効率の減少をきたすことがあげられる。この外部発光効率を向上するた

めに適当な屈折率を持った物質を半導体と空気の間にいれる方法が採用され、一般に表面保護の目的も兼ねて高屈折率の透明エポキシ樹脂あるいは低融点ガラス等が利用される。上記エポキシ系樹脂あるいはガラス体を素子表面に被覆することによって外部発光効率は2～5倍程度になり、さらに適当な形状（先端径，高さ）を選ぶことによって、そのレンズ効果によって見掛上の面積が大きくなることは周知である。しかしながら上記方法によって見掛上の面積を大きくすると前方指向性が大きく即ち半値角が小さくなる欠点が生じ、広い方向、範囲から識別する目的に対しては致命的である。

本考案は上記特長を損うことなく、指向性が大きくなる欠点を解決しうる上記レンズ体の構成に関する。指向性を小さくすることは発光素子ペレットから発した光をレンズ中で散乱せしめることによって達成でき、本考案者の検討結果によれば上記レンズを構成するエポキシ系樹脂あるいは低融点ガラス内に予め所定量の光散乱剤を混入して

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おくことによって上記目的を達成できることが明らかになった。上記光散乱体としてはその散乱作用を持たすために少なくともレンズ構成体より屈折率が高く（エポキシ $n=1.4\sim1.6$，低融点ガラス $n=1.5\sim2.0$）、かつ化学的、電気的に安定な物質が要求される。またレンズ体を形成する際に光散乱体の沈降を軽減するためには比重がレンズ構成体と同程度の物質が望ましい。

しかし本考案者の検討結果によれば上記散乱体の粒径を1μ以下で利用すれば上記比重にはほとんど関係なくほぼ一様に分散されるし、また実施例でも示すように、その製造法によれば粒径が約10μ以下程度であれば逆に沈降作用によって理想的に散乱剤を分散せしめることが明らかになった。上記光散乱体としては、粉体の形成が容易でかつコスト的にも安価で上記緒性質を満足するものとして Al_2O_3（比重 $\rho=3.30\sim3.97$，屈折率 $n=1.64\sim1.68$），ZnO（$\rho=5.47\sim5.78$ $n=2.01\sim2.03$），TiO_2（$\rho=4.26$ $n=2.62\sim2.90$），SnO_2（$\rho=6.95$ $n=2.00\sim2.09$），MgO（$\rho=3.65$ $n=1.74$），PbO（$\rho=9.53$ $n=2.51\sim2.71$）等が実施結果においても好結

果を得た。

以下本考案装置を図面を用いて詳細に説明すると、第1図(a),(b),(c),(d)はそれぞれ本考案による固体発光素子の断面図である。図中において同一個所は同一符号を用いている。同図(a)はトランジスタステム(TO−18)上に$GaAs_{1-x}P_x$のpn接合を用いた発光素子ペレット(2)を図示のごとくマウントしたのち光散乱体を含まないエポキシ樹脂(3)を素子上面に被覆し硬化したのち、その上に光散乱体を含むエポキシ樹脂(4)をコートし形成用型にて加熱硬化させたものである。なお素子ペレット(2)の上部電極からリード線(5)を介して外部取出用端子(6)に接続されている。一方素子ペレット(2)の下部電極(図示せず)から外部取出用端子(7)に接続されている。光散乱体として粒径約10μのSnO_2粉末を用いた場合(エポキシ樹脂1000gに対してSnO_2を2.0g添加)で図示の方向に向けて加熱硬化する際に粒径の大きいものほど沈降が進行し、光散乱剤は図示のごとく分散している。同図(b)は光散乱体として10μ以下のTiO_2を含むエポ

キシ樹脂（エポキシ樹脂1000gに対してTiO_2 1.5g）をコートし、上述の成形用型にて加熱硬化したもので、硬化を完了する以前に素子の方向を回転しながら保持した場合である。光散乱剤は図示のごとく分散している。同図(a),(b)では発光素子ペレット上方に粒度による沈降作用の差によって分散剤の密度がやや大きい部分が存在し、その散乱作用によって理想的な指向性を実現することができる。第2図(a),(b)は上記方法による光散乱剤の有無による光の指向性の代表特性であり、同図(a)は従来の光散乱剤のない場合、同図(b)は光散乱剤の入った場合である。図においてθはエポキシ樹脂(4)の垂直中心軸からの角度を示す。

第1図(c)は粒径1μ以下の選択された微小粒のAl_2O_3 ，MgOを分散剤とした場合で、図示の方向、あるいは逆の方向で硬化させてもほぼレンズ体一様に分散剤を分散させることができる。指向性としても第2図(b)とほぼ同様の特性を実現する。第1図(d)はガラスレンズ付キャップ(8)が予め素子に気密封止されたのち上記キャップガラス前面に上

述の光散乱剤を含むエポキシ樹脂、あるいは低融点ガラスを添加しレンズ体と成形したものである。上記同図(a),(b),(c)と同様に指向性を小さくすることが可能である。特に同図(d)の場合、耐候性、耐水性の点ですぐれている。

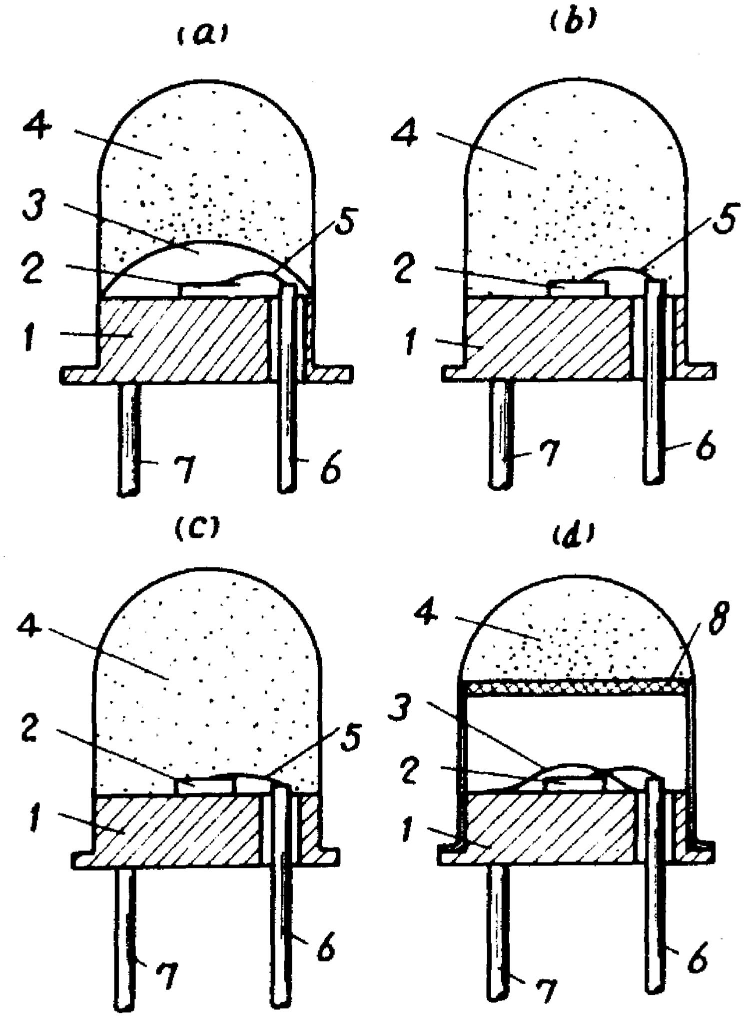
以上いくつかの実施例によって説明したようにレンズ構成体に高屈折率の微量の光散乱体を含有せしめることによって、見掛上の発光面積が大きく、かつ指向性の小さい、実用上非常にすぐれた固体表示ランプが容易に形成される。

4、図面の簡単な説明

第1図(a),(b),(c),(d)はそれぞれ本考案の実施例を示す固体発光装置の断面図、第2図(a),(b)はそれぞれ従来の固体発光装置における光の指向特性図、および本考案の実施例における固体発光装置の光の指向特性図である。

(1)……トランジスタステム、(2)……$GaAs_{1-x}P_x$のpn接合による発光素子ペレット、(4)……光散乱体を含んだエポキシ樹脂、(5)……リード線、(6),(7)……外部取出用端子。

第 1 図



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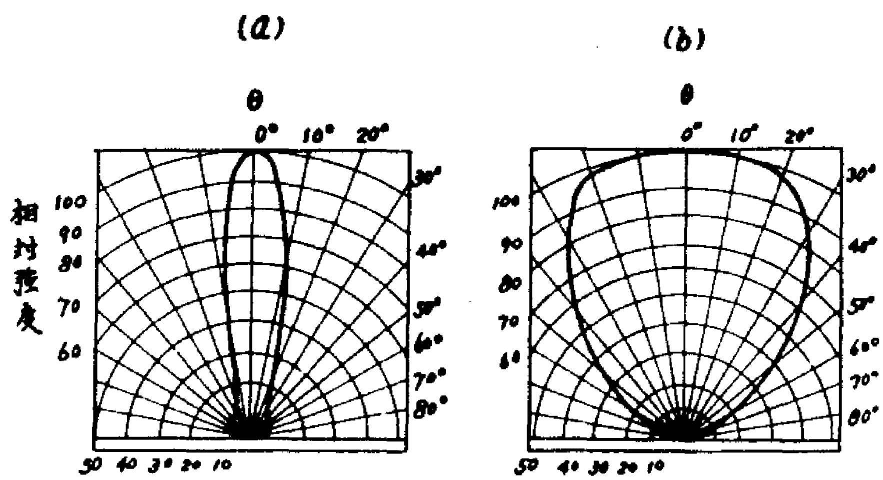
第 2 図



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⑤発光ダイオード素子にけい光体を塗布する方法

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⑰特許請求の範囲

1　赤外発光性の発光ダイオード素子の発光部分を有する端面に赤外線の励起によつて可視光を発するけい光体粉末と、前記けい光体粉末の1～10％の樹脂を溶剤によつて希釈してなる分散媒を付着させ、次いで上記発光ダイオード素子を倒立保持し、その下端に懸垂して付着している上記分散媒中でけい光半粉末が下方に集中沈降した状態のままで、分散媒を乾燥させる事を特徴とする、赤外発光性の発光ダイオード素子に赤外線の励起によつて可視光を発するけい光体を塗布する方法。

発明の詳細な説明

本発明は、発光ダイオード素子にけい光体粉末を塗布する方法に関する。

最近、砒化ガリウム発光ダイオードなどに、不純物などを入れ近赤外域に発光を持つ様にした、赤外発光性の発光ダイオード（以下単に発光ダイオードという）の通常ウエハーと呼ばれる発光部分に、赤外線の励起によつて可視光を発するけい光体（以下単にけい光体という）例えばYF_3：Yb・Er、LaF_3：Yb・Er 等を塗布し可視発光性の発光素子を得る事が試みられている。

この種のけい光体は、赤外強度の累乗に比例して可視発光強度が増すため励起密度を高める必要がある事、可視発光を取り出すためには、けい光体層の厚さが問題になる事、それ自体が特殊なけい光体で極めて高価な事、そして発光ダイオードの発光部分が極めて薄く、大きさも一辺が数百ミクロンの方形で極めて小さい事などから、少量のけい光体を発光部分に集中し接近させて塗布する必要がある。

この様に、小さな表面上に塗布するという事は、高輝度でバラツキの少いけい光体塗膜を得る事が必要であるに拘わらず極めて困難な現状にある。

従来、この様な小さな表面に塗布する方法としては、刷毛塗りあるいは沈降法などの方法がとられている。しかし、これらの方法により小さい表面上に発光部分からの赤外線の全反射をさけて効率良く可視発光を取り出すための、均一なドーム状塗膜を再現性よく得る事は非常に困難であつた。

本発明はこれらの難点を解決した画期的な塗布方法である。本発明によれば、液滴及び粉体の一般的な物理的特性を利用する事により、小さな素子面上に均一なドーム状のけい光体塗膜を再現性良く形成しうる。

本発明の塗布方法は発光ダイオード素子の発光部分を有する端面に、けい光体粉末および分散媒を付着させ、次いで上記発光部分が下方に位置する様に上記発光ダイオード素子を倒立して保持しその下端に懸垂して付着している上記分散媒の液滴中で上記けい光体粉末が下方に集中して沈降した状態で、上記分散媒を乾燥させる事を特徴とするものである。

以下、図面により本発明の方法を更に具体的に示す。

第1図aに示す様に、水平に保たれたダイオード1の発光部分を有する端面の上にけい光体2を直接所要量乗せる(b)。

その上にバインダーとなる樹脂等を、溶剤に溶解した分散媒**3**を、注射器等の細いノズルから適当量滴下する。

滴下された液滴は、自由表面に作用する表面張力により発光端面上に置かれたけい光体等の粉体を包含した状態でドーム状（以下ドームと略称）となる（c参照）。

この様な状態(c)のものを得る手順として上記の外に先に分散媒を滴下しドームを形成している中にけい光体を投下する方法、およびけい光体と分散媒を混合して同時に素速く滴下する方法なども勿論、本発明に包含される。

いずれの方法によるにしろ重要なことは、分散媒がけい光体粉末を包含してドームを形成することである。

以上のようにして(c)を得たら、次にこれを自由表面が下向きになるように半回転させる。すなわち発光ダイオードを倒立して発光部分を有する端面が下向きで水平になるように保持する。かくてけい光体の比重が分散媒より充分大きいため、ドーム状に懸垂した分散媒の液滴内に包含されたけい光体等の粉体は、ドーム液滴内を沈降し、ドームの頂点附近に集まろうとする。かくて液滴内の粉体分布は(d)の如くになる。次いでそのまゝ（自由表面を下向きで、水平に保持した状態）これを適当な温度で乾燥する。

適温乾燥により稀釈溶剤は気化していき、けい光体粉末は樹脂と共に徐々にダイオード発光端面を中心とする附近にドーム状になつて付着する（e参照）。

以上のような方法によつて得られたけい光体の付着したダイオードは通電により発する赤外線を効率良く可視光に変換し、極めて高輝度の緑色発光を呈す。

ダイオードの赤外光を効率良く可視光に変換し、それを外部にとり出すためには前述の如くダイオードにのせるけい光体量、樹脂と溶剤からなる分散媒の組成等により決定する。けいこう体層、密着性、形状等が重要な要素となる。

これらの関係を解明するため、さらに本発明を詳述する。

可視光を最も効率良く取り出すには、ダイオードに付着したけい光体層に最適厚さが存在する。第**6**図にけい光体層の厚みと、外部に取り出された発光（相対）輝度の関係の一例を示した。

この例はバインダーを用いない場合の例であるが、0.2～0.6㎜の範囲で最高輝度が得られるという目安が得られた。次にいくつかの例示樹脂をバインダーとして用いてダイオードにのせるけい光体量を変化させた場合のけい光体量と取り出された輝度の関係を第**2**図に示した。またけい光体量と測定されたけい光体層厚の関係を第**3**図に示した。

これら両図より可視光を最も効率よく取り出す、つまり最大輝度を得るためのけい光体の所要量は各種樹脂の使用に依存せず2から6㎎位であり、けい光体層厚で0.1から0.5㎜の範囲であることが明らかになつた。特に2から4㎎の範囲において最も明らかになつた、特に2から4㎎の範囲において最も再現性良く良好な結果を得る。

バインダーとなる樹脂は

① 可視光を取り出すため透明で耐候性の良い事、

② 発光ダイオードの屈折率が高いので、ドーム状にした時全反射しないようにするため、屈折率がなるべく大きい事、

③ 加熱乾燥するため熱硬化型で金属に対する接着力を有する事、

④ 発光端面や導線部を腐蝕しない事など

を満足させる樹脂が適当である。上記諸条件に合うものとしては、エポキシ樹脂、アクリル樹脂、シリコーン樹脂、ポリスチレンやポリビニールアルコールなどがある。しかし特に良好なものは、前三者である。

樹脂の所要量は現在市販のものでも固型もしくは溶媒に溶かしたものなどがあるため特定はしがたいが、とにかくけい光体粒子相互を結合させ、発光端面附近に付着するに要する最少の量であることが望ましく、いずれも、けい光体量に対する固型樹脂分の重量比にして約1～10％が最適であることが判明した。

樹脂の選択に次いで重要なことは、分散媒を構成する溶剤の種類及びその量の問題である。とにかくけい光体が分散媒中を自由に動くこと及び余分な樹脂分を少なくするため適当な稀釈溶媒を入れることが必要である。

この溶剤は乾燥により気化するため樹脂の様な特性は必要としない。例えばトルエン、アセトン、キシレンなどが挙げられるが色々な樹脂に合せて、

乾燥時徐々に気化する必要が有る為、比較的沸点の高い物を主成分とすることが望ましい。又前記樹脂を良く溶かすという条件も考慮に入れると、トルエンやキシレンが最適である。その所要量は第4図と第5図に示す如く、市販の樹脂溶液（樹脂固型分50％前後）を使用した場合、いずれも重量比で10倍から30倍の範囲が良く、輝度及びけい光体層の形状等の再現性及び取り扱い易さの点から特に20倍附近が最適である。

本発明に於て乾燥温度は、溶剤が徐々に気化し後で樹脂が固まる様に2段階に選ぶのが良く最初の乾燥段階は室温から100℃以下特に70℃附近、後の樹脂硬化はそれぞれ樹脂で当然異るが200℃附近が好ましい。この様にして得られた本発明の発光素子は、可視発光輝度に於いて第2図や第4図に示す如く、高輝度が再現性良く得られる。これは厚みにおいても第6図に示された最適厚附近のけい光体塗膜が第3図や第5図の如く再現性良く得る事ができることによる。そしてその輝度は、刷毛塗り、沈降法など公知の塗布方法に比較し1.5～2倍も明るくなる。

従来公知の塗布方法では、本発明の様に微少部分に収率よくおよび再現性よく高価なけい光体を塗布することとは全く不可能に近い。

本発明の塗布方法は、けい光体と他の粉末を混合して塗布する場合も適用範囲として含むものである。また元々可視発光を出す発光ダイオードの発光端面上に光を拡散する為に光拡散用の粉末を塗布する場合にもその技術を応用することができる。

さらに本発明の塗布方法によりけい光体を塗布した上に、けい光体を含まない樹脂溶液を塗布すると、機械的強度の補強と光の利用率の向上のために一層効果的である。

以下実施例により本発明を詳述する。

実施例　1

シリコン樹脂（トーレシリコーン製 SH－805（固型分50％溶剤キシレン））	1gr
トルエン	10gr
けい光体	4mg

第1図に示すが如く、上記けい光体をダイオードの発光端面上に乗せ、上記樹脂及び溶剤の混合物を注射器の様な細いノズルから数百mg滴下して、ドームを作り、次いで半回転して逆水平にし、60℃位で、1時間程乾燥後、250℃位で4時間乾燥する。

かくて第3図および第4図に示される様な最適な厚みと高輝度を得ることができた。

実施例　2

アクリル樹脂（三菱レーヨン製ダイヤナール1034（固型分30％溶剤キシレン））	1gr
トルエン	15gr
けい光体	3mg

第1図に示すが如く上記けい光体を発光ダイオードの発光端面上に乗せ、上記樹脂及び溶剤の混合物を注射器等の細いノズルから数百mg滴下して、ドームを作り、次いで半回転させ、逆水平にし、60℃位で1時間程乾燥し、更に100℃位で4時間乾燥する事により第3図および第4図に示す様な最適な厚みと高輝度を得た。

実施例　3

エポキシ樹脂（シエル化学製エピコート1004（固型分30％））	1gr
トルエン	10gr
けい光体	3mg

第1図に示す如く、上記けい光体を発光ダイオードの発光端面上に乗せ上記樹脂及び溶剤の混合物を注射器のノズルから数百mg滴下してドームを作り、半回転させ、逆水平にし、60℃位で1時間程乾燥した後、200℃位で2時間乾燥。

かくして第3図および第4図に示す様な最適な厚みと高輝度を得た。

実施例　4

シリコン樹脂（トーレシリコーン製 SH－808（固型分50％溶剤キシレン））	1gr
キシレン	15gr
けい光体	4mg

上記樹脂と溶剤の混合物を注射器で発光ダイオード発光端面上に数百mgに滴下しドームを作り、そのドームの頂点附近にけい光体を注意深く投入し、端面上に沈降させた後、半回転させ、逆水平

にし、60℃位で1時間更に250℃位で2時間乾燥した。かくて、第3図及び第4図に示されるのと同様な良好な厚みと高輝度が得られた。

図面の簡単な説明

第1図は本発明による塗布方法を簡単にその順序に従い示したものである。第2図は本発明の塗布方法を適用して、赤外発光ダイオードに赤外可視変換けい光体を塗布した場合の分散媒を一定としたけい光体重量と可視光輝度の関係を示すものである。第3図は第2図に関連する物の、けい光体重量と塗布厚の関係である。第4図は本発明の塗布方法を適用して、赤外発光ダイオードに赤外可視変換けい光体を塗布した場合のけい光体重量を一定とした分散媒中の樹脂溶液（樹脂固型分を約50％溶剤に溶かした市販の物）対稀釈溶剤比と可視発光輝度の関係を示すものである。第5図は第4図の樹脂溶液対稀釈溶剤比と塗布厚の関係を示すものである。第6図はけい光体の厚みと輝度の関係を示すものである。

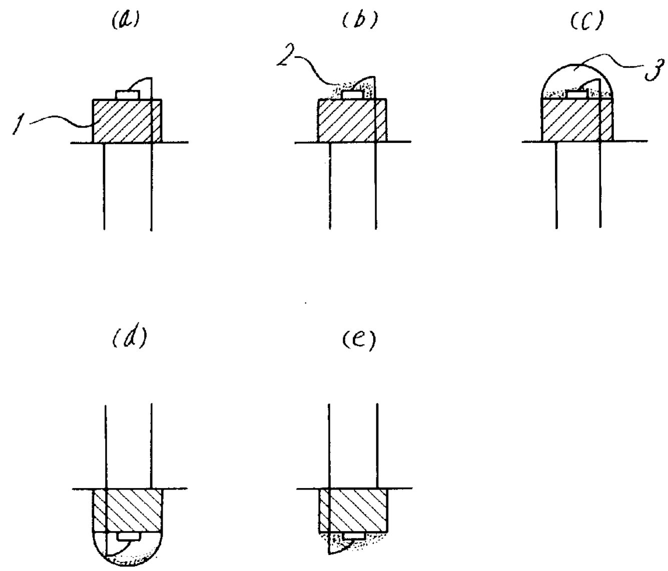
⑯引用文献

特　公　昭46－9194

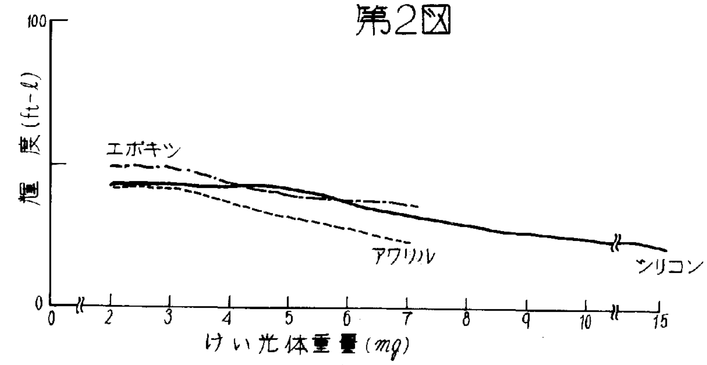
米国特許　3510732（クラス317－234）

Jownal of Electrochemicai Society 116〔12〕P.P.1718～1722'69－12

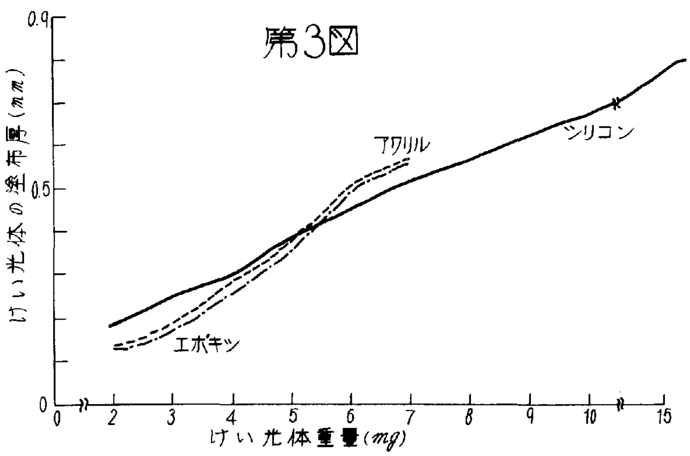
第1図


(a)
(b)
(c)
(d)
(e)
1
2
3

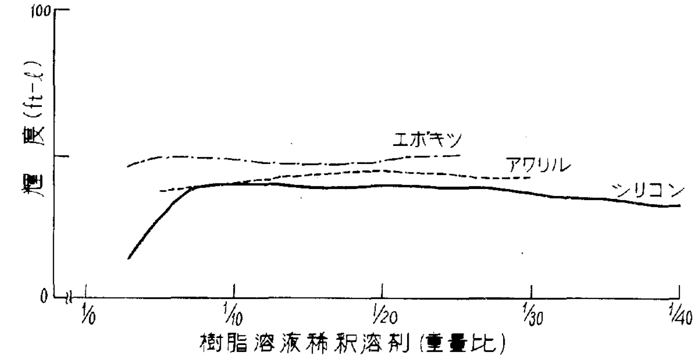
第2図


輝度(ft-l)
エポキシ
アクリル
シリコン
けい光体重量(mg)
100
0
2
3
4
5
6
7
8
9
10
15

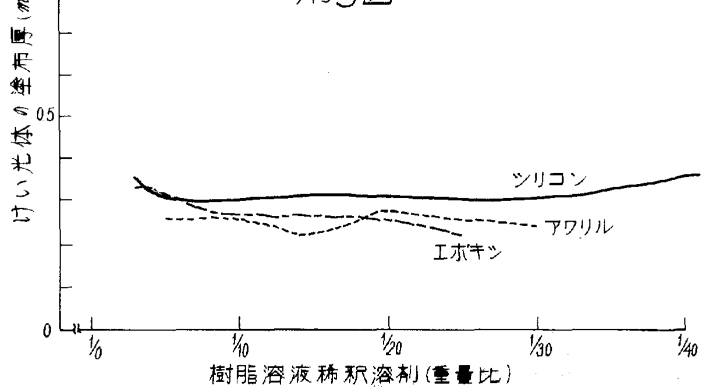
第3図


けい光体の塗布厚(mm)
アクリル
シリコン
エポキシ
けい光体重量(mg)
0.9
0.5
0
2
3
4
5
6
7
8
9
10
15

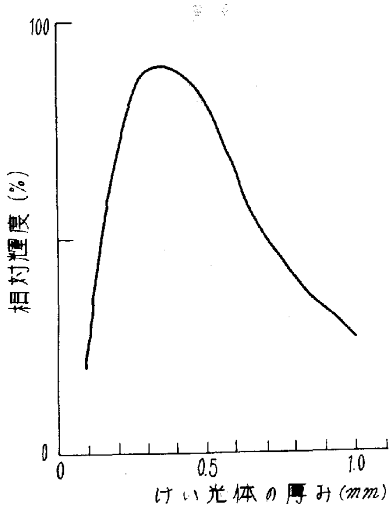
第4図


100
0
輝度(ft-ℓ)
エポキシ
アクリル
シリコン
1/10
1/20
1/30
1/40
樹脂溶液稀釈溶剤(重量比)

第5図


0.8
0.5
0
けい光体の塗布厚(mm)
シリコン
アクリル
エポキシ
1/10
1/20
1/30
1/40
樹脂溶液稀釈溶剤(重量比)

第6図


100
0
相対輝度(%)
0
0.5
1.0
けい光体の厚み(mm)

(2) 発明の数なし

実用新案登録願（実用新案法第8条第1項の規定による実用新案登録出願）

収入印紙 3,000円

昭和 52年 9月 13日

(3,000円)

特許庁長官 殿

50-59514

1. 考案の名称 波長変換装置（ハチョウヘンカンソウチ）
2. 原特許出願の表示 昭和50年特許願第059514号（昭和50年5月21日）
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特許庁 52.9.13 出願第二課

52 122371

明　細　書

1. 考案の名称

波長変換装置

2. 実用新案登録請求の範囲

励起光源と、この励起光源を半球状に直接被う波長変換体と、この波長変換体から十分隔離して設けられて励起波長光及び変換波長光を垂直に受ける干渉フィルタとを備え、この干渉フィルタは励起波長光に対して反射率が高く且つ変換波長光に対して透過率が高いことを特徴とした波長変換装置。

3. 考案の詳細な説明

本考案は例えば光源として用いる波長変換装置に関し、具体的には励起波長光の反射率が高く、変換波長光の透過率の高い干渉フィルタと励起発光素子及び波長変換螢光体との光学的結合により、実効的波長変換効率を高めると同時に励起波長光を除去し、変換波長光のみを発光させるようにしたことを特徴とする波長変換装置に関するものである。

従来、例えば赤外光を可視光に変換する材料として希土類イオンを含むいくつかの螢光体その他が見い出されている。例えばYb－Er，Yb－Tm，Yb－Hoの組合せを含むYOC l，YF_3，LaF_3 等の螢光体では波長0.9～1.0 μmの赤外光励起により赤，緑，青等の可視発光が得られることが知られている。

第1図は従来の赤外－可視波長変換装置の一例を示すものであり、*1* はヘッダ、*2* は波長約0.94 μmの赤外光を放射する発光素子、*3* はエポキシレンズ、*4* は赤外光を吸収して可視光及び赤外光を同時に放射する波長変換螢光体、*5* は可視光を透過し且つ赤外光を前記螢光体 *4* で再利用すべく反射する干渉フィルタである。

ここで用いる干渉フィルタ *5* は一般に誘電体の多層膜より構成され、所定の波長光を選択的に透過または反射させる。

透過及び反射の波長は、干渉フィルタの膜厚と直接関係があり、そのためにまた干渉フィルタの特性は、入射角が0°の光線に対して所定の特性を

示すように設計されており、入射角が0°からずれるに従いその特性は大幅に変化する。

第1図の構造においては、螢光体4の上に直接干渉フィルタ5を被着しているため、発光素子2で放射された直接の赤外光は干渉フィルタ5で反射されるが、螢光体4で発生した赤外光の大部分は干渉フィルタ5に垂直に入射せず、そのため一部分のみ反射される欠点がある。更に螢光体4で発生した可視光の大部分も干渉フィルタに垂直に入射せず、そのため干渉フィルタから取り出し得る可視光の効率が低い欠点がある。

本考案はこれらの点に着目し、励起光を有効に利用することにより実効的な変換効率を高めるものであり、それと同時に変換光のみを取り出すことを可能にするものである。

第2図は本考案の一実施例を示す赤外－可視変換装置の断面図で、半球のエポキシレンズ24の中心に波長変換螢光体23を塗布した発光素子22があり、赤外光の反射率が100％、可視光の透過率の高いドーム状の干渉フィルタ25およ

びヘツダ21から構成されている。

尚26はエポキシレンズと干渉フイルタとの間隙であり、干渉フイルタの取りはずしをしたい場合は、空気又は不活性ガスで充填するか、あるいは光の屈折率整合を兼ねてシリコングリース等の非固化物を充填する方が好ましい。又取りはずしを行なわない場合はこの間隙をなくしエポキシレンズ24と干渉フイルタ25とを密着して固定し使用することも可能である。

また、発光素子22から放射される赤外光の大部分は螢光体23に吸収され変換可視光及び赤外光を放射する。変換可視光は破線で示すようにエポキシレンズ24、干渉フイルタ25を通して外部に取り出される。一方、螢光体23に吸収され再発光した赤外光及び螢光体23を透過した赤外光は実線で示すように干渉フイルタ25にほぼ垂直に入射し、100％反射されて入射光路とほぼ同じ光路を通つて再び螢光体23に照射され、その大部分は吸収されて赤外－可視変換に寄与する。このように赤外光は外部に放射されることなく、

繰返し螢光体23を照射するので、変換効率を大巾に改善することが出来る。

第3図は本考案の他の実施例を示す赤外－可視変換装置の構造を示す断面図で、変換可視光を有効に集光可能な光源として利用価値の大きいものである。第3図において、31はヘッダ、34は赤外光及び可視光をよく反射する回転放物面鏡であり、その焦点に波長変換螢光体33を塗布した発光素子32が位置している。

螢光体33より放射される可視光及び赤外光は放物面鏡34で反射されて、前述の特性を持つ平板状の干渉フィルタ35に入射する。ここで可視光の大部分は破線で示すように干渉フィルタ35を透過して外部に取り出されるが、赤外光は実線で示すように100％近く反射され同じ光路を通って螢光体33に照射され、再吸収されて赤外－可視変換に寄与し変換効率の改善に役立つ。

以上の説明から明らかなように、本考案では、発光素子を波長変換体で直接被い、変換波長光及び励起波長光並びに励起光が干渉フィルタへ垂直

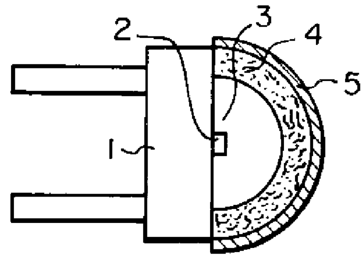
に入射できる程度に干渉フイルタと波長変換体との間隔を十分とつているため、変換効率の大幅な改善が可能になる。なお、表示装置等に利用する場合、波長変換体と干渉フイルタとの間の間隔をとり過ぎると表示面が暗くなることが懸念されるが、発光素子面積を500μm×500μmとした場合、波長変換体の面積を2㎜×2㎜とし且つ波長変換体と干渉フイルタとの間隔を2㎝程度にすれば、変換波長光その他がほぼ垂直に干渉フイルタへ入射し、従つて実際上の問題は生じない。

4. 図面の簡単な説明

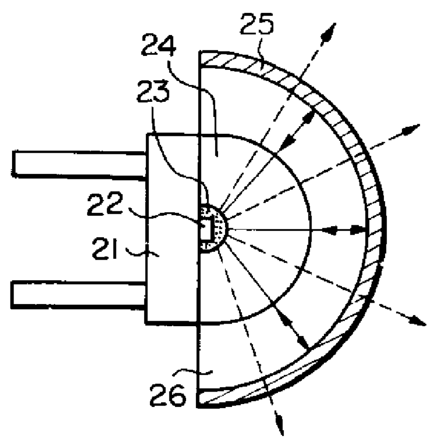
第1図は従来の波長変換装置を示す断面図、第2図と第3図はそれぞれ本考案の実施例を示す波長変換装置の断面図である。

21…ヘツダ、22…発光素子、23…波長変換螢光体、24…エポキシレンズ、25…干渉フイルタ、26…エポキシレンズと干渉フイルタとの間隙、31…ヘツダ、32…発光素子、33…波長変換螢光体、34…回転放物面鏡、35…干渉フイルタ。

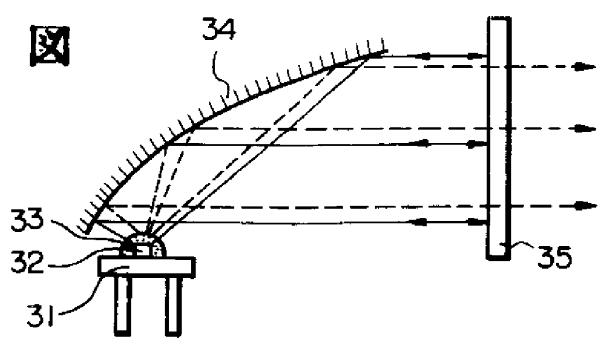
第1図



第2図



第3図



実用新案登録出願人 沖電気工業株式会社

代理人 鈴 木 敏 明

13985

6. 添付書類の目録

(1)	明 細 書	1 通	
(2)	図 面	1 通	
(3)	委 任 状	1 通	（変更を要しないため省略する。）
(4)	願 書 副 本	1 通	
(5)	出願審査請求書	1 通	

53-43885

PATENT ABSTRACTS OF JAPAN

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(51)Int.Cl. H01L 33/00

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(22)Date of filing : 27.12.1993

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(72)Inventor : TOMIYAMA YASUYOSHI
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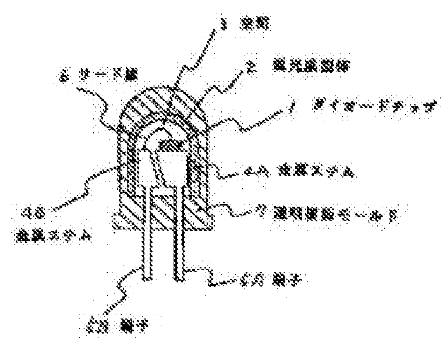
ISHIWATARI MASAHARU

(54) INFRARED VISIBLE LIGHT CONVERSION LIGHT EMITTING DIODE OF SMALL DIRECTIVITY

(57)Abstract:
PURPOSE: To remarkably reduce directivity and make possible clear indication in the case of large size, by fixing a fluorescent molded object which dispersedly contains infrared visible light conversion phosphor, so as to keep a specified distance from an infrared light emitting diode.
CONSTITUTION: A fluorescent molded object 2 is arranged in the manner in which the inner surface is positioned so as to keep a specified distance, e.g. 1.0mm, from the upper surface of a diode chip 1. For the purpose of protection, the whole part containing the fluorescent molded object 2 is packaged by using a transparent resin mold 7, and conversion light emitting diodes 1-3 are manufactured. A phosphor layer is formed as a dome type fluorescent molded body 2, which is arranged so as to keep a specified distance from the diode chip 1. Thereby the directivity caused by the difference of luminance in the observation direction is reduced, so that clear indication can be obtained.



CLAIMS

[Claim(s)]
[Claim 1]In an infrared visible conversion light emitting diode which converts and emits infrared light which an infrared emitting diode emits to visible light using an infrared visible conversion fluorescent substance, Few directive infrared visible conversion light emitting diodes which provide a predetermined distance and equip with a dome state resin molded body which carries out distributed content of the infrared visible conversion fluorescent substance to an infrared light emitting diode chip.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to the infrared visible conversion light emitting diode (henceforth a conversion light emitting diode) widely used for the display.
[0002]
[Description of the Prior Art]Generally conventionally a conversion light emitting diode An infrared light-emitting part and an infrared visible conversion fluorescent substance content resin layer. It becomes (calling it a phosphor layer hereafter) from a wrap transparent resin mold about it, As shown in the outline cross sectional view of Fig.2, an infrared light-emitting part The infrared light emitting diode chip 1. Similarly bonding of the P type layer is carried out for the N type layer of (calling it a diode chip hereafter) to the metal stem 4A through the lead 6 at the metal stem 4B, And the metal stems 4A and 4B consist of a thing of the terminals 5A and 5B and one, The aforementioned phosphor layer 8 is formed by applying to the diode chip 1 the epoxy resin which carries out distributed content of the powder of an infrared visible conversion fluorescent substance (henceforth a conversion fluorescent substance), and the infrared light-emitting part and the phosphor layer 8 are packed by the transparent resin mold 7.
[0003]In the above-mentioned conversion light emitting diode, among the terminals 5A and 5B, apply voltage and the Kon side of the PN-junction surface of the diode chip 1 emits infrared light clitteringly, While this infrared light passes the above-mentioned phosphor layer 8, it is absorbed into a conversion fluorescent substance, converts to the visible light of a specified wavelength, and is emitted to outside through the transparent resin mold 7.
[0004]
[Problem to be solved by the invention]However, although enlargement of a conversion light emitting diode is remarkable in recent years and it came to have high luminosity, Since the phosphor layer is generally formed by application or dropping on the diode chip in the above-mentioned conventional conversion light emitting diode, The actual condition is that uniform covering not only becomes difficult, but the directivity that luminosity differs cannot but appear and a display cannot but become indistinct by an observation direction as a result.
[0005]
[Means for solving problem]Then, a clear display is obtained even if it enlarges the inventors from the above viewpoints, The result of having inquired few directive light emitting diodes being developed, The phosphor layer in a light emitting diode conventionally [above-mentioned] The fluorescent substance molding body of dome state. It presupposed (it is hereafter called a fluorescence molding body), and when this was made into the structure which provided and installed so predetermined a distance in the diode chip, the research result that the directivity resulting from the difference of the luminosity by an observation direction decreased, and a clear display was obtained was obtained.
[0006]In the conversion light emitting diode which this invention is made based on the

above-mentioned research result, and converts and emits the infrared light which an infrared emitting diode emits to visible light using a conversion fluorescent substance, It has the characteristics in the conversion light emitting diode which lessened directivity by providing a predetermined distance to a diode chip and equipping with a fluorescence molding body.
[0007]
[Working example]Next, the conversion light emitting diode of this invention is specifically described according to an working example. Dispersion mixing of three kinds of conversion fluorescent substances shown in Table 1 is carried out to an epoxy resin at a ratio shown in the table 1, This is made into a fluorescence molding body (the outer diameter of 3.0 mm, 3.0 mm in height, and 0.5 mm in thickness), A fluorescence molding body is installed so that the distance of 1.0 mm may be left so much on the upper surface with the structure same so that Fig.1 may see as the light-emitting part in the above-mentioned conventional conversion light emitting diode of a diode chip and an inner surface may be placed at it, The present invention conversion light emitting diodes 1-3 were manufactured, respectively by packing the whole which contains a fluorescence molding body for the purpose of protection by the transparent resin mold 7. Next, about the present invention conversion light emitting diodes 1-3 obtained as a result, Infrared light is emitted from the diode chip 1 by applying the voltage of about 1.2 volts among the terminals 5A and 5B in order to evaluate the directional characteristics of visible light, and sending the current of a 20-mA forward direction, In the position which is distant from the surface of the transparent resin mold 7 30 cm at an angle of 30 degree to the center line of a conversion light emitting diode, visible luminous intensity, Along with the level surface top circumferential direction, every 60 degree, on the vertical plane which measures using a light power meter and includes the aforementioned center line, relative intensity was computed by having set to 100 strength which was measured with the predetermined angle of inclination by having made the diode chip 1 into the central point, and was measured on the center line, and this calculation strength was shown in Table 1.
[0008]While applying a phosphor layer with an average thickness of 0.5 mm instead of a fluorescence molding body as shown in Fig.2 for the comparative purpose, Except packing without formation of space, visible luminous intensity was measured on the conditions conventionally same about the conversion light emitting diodes 1-3 manufactured on the same conditions, similarly relative intensity was computed, and it was shown in Table 1.
[0009]
[Table 1]

	種別	変換蛍光体の種類	樹脂との混合割合 (%)	測定波長 (nm)	放射可視光の相対強度（光軸上の強度＝100）										
					水平面上円周方向の角度						ﾀﾞｲｵｰﾄﾞﾁｯﾌﾟを中心点とした傾斜の角度				
					0度	60度	120度	180度	240度	300度	光軸上	30度	60度	90度	120度
本発明変換発光ﾀﾞｲｵｰﾄﾞ	1	$(Ba_{0.8}Er_{0.2})Cl_3$	10	550	80	80	80	80	80	80	100	95	80	60	30
	2	$(3GdBr_3ErBr_3)_{0.3}(ZnBr_2)_{0.7}$	20	550	83	83	83	83	83	83	100	95	83	65	35
	3	$GdI_3+(Na_{0.9}Er_{0.1})I_3$	30	555	85	85	85	85	85	85	100	95	85	70	35
従来変換発光ﾀﾞｲｵｰﾄﾞ	1	$(Ba_{0.8}Er_{0.2})Cl_3$	10	550	60	45	45	60	45	45	100	95	60	20	< 5
	2	$(3GdBr_3ErBr_3)_{0.3}(ZnBr_2)_{0.7}$	20	550	50	40	40	55	45	40	100	95	50	10	< 5
	3	$GdI_3+(Na_{0.9}Er_{0.1})I_3$	30	555	45	30	35	50	30	30	100	95	45	5	< 5

[0010]Although the inner surface of the aforementioned dome state molding body is coated with the film which reflects visible light although infrared light transmits in a present invention light emitting diode or visible light similarly transmits an outer surface, if coating treatment of the infrared light is carried out with the film to reflect, it can raise luminosity much more. In order to protect a light-emitting part, the inside of a fluorescence molding body may be filled up with transparent resin.

[0011]

[Effect of the Invention]The present invention conversion light emitting diodes 1-3 show little uniform strength with remarkable dispersion by the position of observation as compared with a conversion light emitting diode conventionally so that clearly from Table 1, and even if directivity makes it large-sized few therefore extremely, that a clear display is attained etc. has the useful characteristic on industry.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The cross sectional view of a present invention conversion light emitting diode
[Drawing 2]The cross sectional view of the conventional conversion light emitting diode
[Explanations of letters or numerals]
1. Diode chip
2. Fluorescence molding body
3. Space
4A.4B. Metal stem
5A.5B. Terminal
6. Lead
7. Transparent resin mold
8. Phosphor layer

[Translation done.]

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(54)【発明の名称】　指向性の少ない赤外可視変換発光ダイオード

(57)【要約】

【目的】　指向性の少ない赤外可視変換発光ダイオードを提供する。

【構成】　赤外発光ダイオードの放射する赤外光を赤外可視変換蛍光体を用いて可視光に変換して放射する赤外可視変換発光ダイオードにおいて、赤外可視変換蛍光体を分散含有するドーム状樹脂成型体を赤外発光ダイオードチップに対して所定の距離を設けて装着する。

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【特許請求の範囲】

【請求項1】　赤外発光ダイオードの放射する赤外光を赤外可視変換蛍光体を用いて可視光に変換して放射する赤外可視変換発光ダイオードにおいて、赤外可視変換蛍光体を分散含有するドーム状樹脂成型体を赤外発光ダイオードチップに対して所定の距離を設けて装着してなる指向性の少ない赤外可視変換発光ダイオード。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、表示用などに広く用いられている赤外可視変換発光ダイオード（以下、変換発光ダイオードという）に関するものである。

【０００２】

【従来の技術】従来、一般に変換発光ダイオードは赤外発光部と赤外可視変換蛍光体含有樹脂層（以下、蛍光体層という）とそれを覆う透明樹脂モールドよりなり、赤外発光部は図２の概略断面図に示されるように赤外発光ダイオードチップ１（以下、ダイオードチップという）のＮ型層を金属ステム４Ａに、同じくＰ型層をリード線６を経て金属ステム４Ｂにボンディングしてなり、かつ金属ステム４Ａ、４Ｂは端子５Ａ、５Ｂと一体のものからなり、また前記蛍光体層８は赤外可視変換蛍光体（以下、変換蛍光体という）の粉末を分散含有するエポキシ樹脂をダイオードチップ１に塗布することによって形成され、赤外発光部と蛍光体層８が透明樹脂モールド７でパッケージされている。

【０００３】また、上記変換発光ダイオードにおいては、端子５Ａと５Ｂの間に電圧を加えてダイオードチップ１のＰＮ接合面の近傍からから赤外光を放射し、この赤外光が上記の蛍光体層８を通過する間に変換蛍光体に吸収されて特定波長の可視光に変換され透明樹脂モールド７を通って外部へ放出される。

【０００４】

【発明が解決しようとする課題】しかし、近年変換発光ダイオードの大型化はめざましく、高い輝度を持つようになったが、上記の従来変換発光ダイオードにおいては蛍光体層が一般に塗布あるいは滴下などによってダイオードチップ上に形成されているので、均一な被着が困難となるばかりでなく、この結果観察方向によって輝度が異なるという指向性があらわれ、表示が不鮮明にならざるを得ないというのが現状である。

【０００５】

【課題を解決するための手段】そこで、本発明者らは上述のような観点から、大型化しても鮮明な表示の得られる、指向性の少ない発光ダイオードを開発すべく研究をおこなった結果、上記従来発光ダイオードにおける蛍光体層をドーム状の蛍光体成型体（以下、蛍光成型体という）とし、これをダイオードチップにたいして所定の距離を設けて設置した構造とすると観察方向による輝度の差に起因する指向性が少なくなって鮮明な表示が得られるという研究結果を得たのである。

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【０００６】この発明は、上記の研究結果にもとづいてなされたものであって、赤外発光ダイオードの放射する赤外光を変換蛍光体を用いて可視光に変換して放射する変換発光ダイオードにおいて、ダイオードチップに対して所定の距離を設けて蛍光成型体を装着することにより指向性を少なくした変換発光ダイオードに特徴を有するものである。

【０００７】

【実施例】次に、この発明の変換発光ダイオードを実施例により具体的に説明する。表１に示される３種類の変換蛍光体を同表１に示される割合でエポキシ樹脂に分散混合し、これを外径３．０mm、高さ３．０mm、厚さ０．５mmの蛍光成型体とし、図１に見られるように前述の従来変換発光ダイオードにおける発光部と同じ構造を持つダイオードチップの上面にたいして１．０mmの距離を離れて内面が位置するように蛍光成型体を設置し、更に保護の目的で蛍光成型体を含む全体を透明樹脂モールド７でパッケージすることにより本発明変換発光ダイオード１～３をそれぞれ製造した。つぎに、この結果得られた本発明変換発光ダイオード１～３について、可視光の指向特性を評価する目的で端子５Ａと５Ｂの間に約１．２ボルトの電圧を加え２０ｍＡの順方向の電流を流すことによってダイオードチップ１より赤外光を放射し、可視光の強度を変換発光ダイオードの中心線に対して３０度の角度で透明樹脂モールド７の表面から３０ｃｍ離れた位置で、水平面上円周方向に沿って６０度毎に、光パワーメーターを用いて測定し、また前記中心線を含む垂直面上で、ダイオードチップ１を中心点として所定の傾斜角で測定し、中心線上で測定した強度を１００として相対強度を算出し、この算出強度を表１に示した。

【０００８】比較の目的で図２に示されるとおり、蛍光成型体に代わって平均厚さ０．５mmの蛍光体層を塗布するとともに、空間の形成なくパッケージすること以外は同一の条件で製造した従来変換発光ダイオード１～３について同一の条件で可視光の強度を測定し同じく相対強度を算出して表１に示した。

【０００９】

【表１】

	種別	変換蛍光体の種類	樹脂との混合割合(%)	測定波長(nm)	放射可視光の相対強度（光軸上の強度＝100）										
					水平面上円周方向の角度						ダイオードチップを中心点とした傾斜の角度				
					0度	60度	120度	180度	240度	300度	光軸上	30度	60度	90度	120度
本発明変換発光ダイオード	1	$(Ba_{0.8}Er_{0.2})Cl_3$	10	550	80	80	80	80	80	80	100	95	80	60	30
	2	$(3GdBr_3.ErBr_3)_{0.3}(ZnBr_2)_{0.7}$	20	550	83	83	83	83	83	83	100	95	83	65	35
	3	$GdI_3+(Na_{0.9}Er_{0.1})I_3$	30	555	85	85	85	85	85	85	100	95	85	70	35
従来変換発光ダイオード	1	$(Ba_{0.8}Er_{0.2})Cl_3$	10	550	60	45	45	60	45	45	100	95	60	20	<5
	2	$(3GdBr_3.ErBr_3)_{0.3}(ZnBr_2)_{0.7}$	20	550	50	40	40	55	45	40	100	95	50	10	<5
	3	$GdI_3+(Na_{0.9}Er_{0.1})I_3$	30	555	45	30	35	50	30	30	100	95	45	5	<5

【００１０】なお、本発明発光ダイオードにおいては赤外光は透過するが可視光を反射する被膜で前記ドーム状成型体の内面をコーティングしたり、同じく外面を可視光は透過するが赤外光は反射する被膜でコーティング処理したりするとより一段と輝度を高めることが出来る。

さらに、発光部を保護するために蛍光成型体の内部を透明樹脂で充填してもよい。

【００１１】

【発明の効果】表１から明らかなように、本発明変換発光ダイオード１～３は従来変換発光ダイオードに比して観測の位置によるばらつきが著しく少なく均一な強度を示し、極めて指向性が少なく、従って、大型にしても鮮明な表示が可能となるなど工業上有用な特性を有する。

【図面の簡単な説明】

【図１】　本発明変換発光ダイオードの断面図

【図２】　従来変換発光ダイオードの断面図

【符号の説明】

１．　ダイオードチップ

２．　蛍光成型体

３．　空間

４Ａ．４Ｂ．　金属ステム

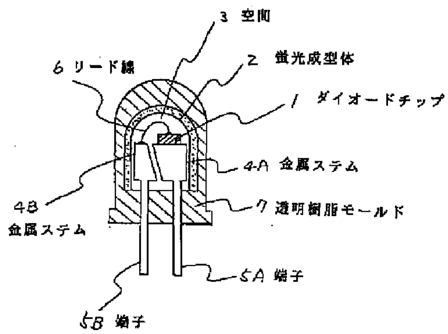
５Ａ．５Ｂ．　端子

６．　リード線

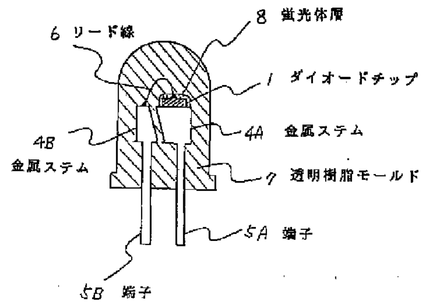
７．　透明樹脂モールド

８．　蛍光体層

【図1】


3 空間
2 蛍光成型体
6 リード線
1 ダイオードチップ
4A 金属ステム
4B 金属ステム
7 透明樹脂モールド
5A 端子
5B 端子

【図2】


8 蛍光体層
6 リード線
1 ダイオードチップ
4A 金属ステム
4B 金属ステム
7 透明樹脂モールド
5A 端子
5B 端子

Electronic Acknowledgement Receipt

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Confirmation Number:	7704
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First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/Patti Young
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Time Stamp:	12:16:26
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20121218IDS.pdf	531011 07dd04a12437260b5d2ff71557232285ac2d417d	yes	10

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Transmittal Letter		1	8	
	Information Disclosure Statement (IDS) Form (SB08)		9	10	
Warnings:					
Information:					
2	Foreign Reference	JP2000286455.pdf	6851969 3e01b2d2b6ea92df44fd0adbf959655633816594	no	22
Warnings:					
Information:					
3	Foreign Reference	JP48039866.pdf	183576 07cbebbc64a75d3766585c2cd28d560b607c5daa	no	11
Warnings:					
Information:					
4	Foreign Reference	JP52040959.pdf	368474 d35d0bd5540abf5bcf145ace40bafe35c0ba5d4e	no	6
Warnings:					
Information:					
5	Foreign Reference	JP53043885.pdf	159183 5cb1bb198659f30a398a9408883b1a8621e25064	no	9
Warnings:					
Information:					
6	Foreign Reference	JP7193281.pdf	1639577 1dd1bb2799f29096be807128902974be642e59a4	no	11
Warnings:					
Information:					
7	Non Patent Literature	ExperimentalReport.pdf	2190829 5e8796169d35cdd846916a8161e6ea3e7a6e66c3	no	11
Warnings:					
Information:					
8	Non Patent Literature	MeasurementServiceReport.pdf	10383803 d38a751d3efe6fdea2b987f723651b8814b1b95c	no	57
Warnings:					
Information:					

9	Non Patent Literature	EmailCorrespondencesFromDowCorning.pdf	219439 233aaf354c3a669f31427f4589c31b22625ae3e3	no	4
Warnings:					
Information:					
10	Non Patent Literature	PhosphorHandbook.pdf	346518 06e7049314e4f2ad1aa60caebcfbe1869c6a951f	no	7
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11	Non Patent Literature	NotificationCN2006100958374dated20120910.pdf	8567778 132cc41cc5db7d4a9c0ff97eea60de0f01f0cd87	no	89
Warnings:					
Information:					
12	Non Patent Literature	USOA12575155dated20121004.pdf	995341 9f02c3767074a949b8d7ac79c7b307f1aec923cb	no	19
Warnings:					
Information:					
13	Non Patent Literature	USOA12689681dated20120907.pdf	654675 8b9315aabcaa7c06e6cab8a49e9a499cdad466e6	no	12
Warnings:					
Information:					
14	Non Patent Literature	USOA12947470dated20121115.pdf	459333 f05a60e9164435c410715e40425a0d3a710bf7f4	no	12
Warnings:					
Information:					
15	Non Patent Literature	USOA13210027dated20121002.pdf	961671 59a92c81700ed3695c583301149df7fb5434a7dc	no	18
Warnings:					
Information:					
		Total Files Size (in bytes):	34513177		

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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

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☑ a. Copies of foreign patent documents, non-patent literature and other information are provided.

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date

12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract and a full English machine-generated translation are provided for the following reference(s): JP 2000-286455 and JP 7-193281.

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

US Office Actions issued in co-pending applications US 12/689,681, US 13/210,027, US 12/575,155 and US 12/947,470 and references cited therein are submitted in this IDS.

Enclosed also is a Notification from the Chinese Patent Office issued in Chinese Patent No. 200610095837.4, which is a counterpart Chinese application of the present US application. First, a Request for Invalidation was submitted to the Chinese Patent Office by a third party. Then, on September 10, 2012, the Chinese Patent Office dispatched a Notification of Acceptance of the Request for Invalidation for informing of the fact that a third party submitted a Request for Invalidation. The Request for Invalidation, with the Notification of Acceptance of Request for Invalidation of Chinese Patent No. 200610095837.4, dispatched on September 10, 2012, is submitted herein. References (5) - (13) included in the present IDS on the attached PTO/SB/08 form were cited in this Request for Invalidation by the third party. A concise explanation of references (5)-(13) follows.

- Reference (7) on the attached PTO/SB/08a form - JP 52-040959 B with bibliographic data.

Concise Explanation:

This document has been cited in a cancellation action against one of the counterpart family patents in Japan and China. It is alleged in the third party Request for Invalidation that this document discloses to use a sedimentation of phosphor particles in a dispersion medium to form a dome-shaped phosphor layer with reference to Fig. 1 (a) to (e).

- Reference (8) on the attached PTO/SB/08a form - JP 53-043885 U with bibliographic data

Concise Explanation:

This document has been cited in a cancellation action against one of the counterpart family patents in China. It is alleged in the third party Request for Invalidation that this document discloses that some technical effects can be expected by changing a location of phosphors in an LED, with reference to Figs. 1 and 2, in which phosphors are shown as elements 4 and 23.

- Reference (9) on the attached PTO/SB/08a form - JP 7-193281 A with a full English machine translation

Concise Explanation:

This document has been cited in a cancellation action against one of the counterpart family patents in China. It is alleged in the third party Request for Invalidation that this document discloses that some technical effects can be expected by changing a location of phosphors in an LED, with reference to Figs. 1 and 2, in which phosphors are shown as elements 2 and 8, and paragraphs 0005 to 0007.

- Reference (6) on the attached PTO/SB/08a form - JP 48-039866 U with bibliographic data

Concise Explanation:

This document has been cited in a cancellation action against one of the counterpart family patents in China. It is alleged in the third party Request for Invalidation that this document teaches that a concentration gradient can be produced by using a natural sedimentation, with reference to Fig. 1 (a) and (b), in which light scattering agent is shown as small dots in the element 4.

- Reference (10) on the attached PTO/SB/08a form) - An experimental report prepared by a requester (third party) of the cancellation action with a title "An experimental result of packages having different phosphors and colloids" [Prepared Date: unknown]

Concise Explanation:

This experimental report was cited in a cancellation action against one of the counterpart family patent in China. It is alleged in the third party Request for Invalidation that this report shows that a concentration distribution of phosphor particles does not delay deterioration of phosphors by a moisture.

- Reference (13) on the attached PTO/SB/08a form) - Phosphor Handbook [Published Date: December 25, 1987]

Concise Explanation:

This document was cited in a cancellation action against one of the counterpart family patent in Japan and China. The document discloses a method for estimating size of phosphor particles by measuring a sedimentation speed of particles in a medium.

- Reference (11) on the attached PTO/SB/08a form – "Measurement service report" prepared by Industrial Technology Research Institute in Taiwan [Prepared Date: May 4, 2012]

Concise Explanation:

This experimental report was cited in a cancellation action against one of the counterpart family patent in Japan and China. It is alleged in the third party Request for Invalidation that the report shows that phosphor particles will naturally fall down in JCR6122 resin.

- Reference (12) on the attached PTO/SB/08a form - E-mail correspondences sent from Dow Corning Toray Co., Ltd. to the requester of the cancellation action. [E-mail Date: September 28, 2011]

Concise Explanation:

This e-mail correspondence was cited in a cancellation action against one of the counterpart family patent in Japan and China. It is alleged in the third party Request for Invalidation that the e-mail correspondence shows that JCR6122 resin was available for encapsulation of LEDs since 1990.

- Reference (5) on the attached PTO/SB/08a form) - JP 2000-286455 A with a full English machine translation

Concise Explanation:

This patent was filed by the assignee of the present application (Nichia Corporation) and cited in a cancellation action against one of the counterpart family patent in Japan and China. It is alleged in the third party Request for Invalidation that the patent discloses that a resin having a viscosity of 500 to 1000 cps is used considering ease of molding, and that the patent discloses that heavy inorganic phosphors tend to settle down in a low viscosity resin with reference to paragraph 0008.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance or before an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance or after an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: December 18, 2012

Respectfully submitted,

Reg. No. 64042

By Corina Tanasa

for D. Richard Anderson
Registration No.: 40,439 CORINA TANASA

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Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☑ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☑ Other: US Office Actions as enclosed.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 03/12/2013

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EXAMINER	
GUPTA, RAJ R	

ART UNIT	PAPER NUMBER
2829	

NOTIFICATION DATE	DELIVERY MODE
03/12/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Office Action Summary	Application No. 12/559,042	Applicant(s) SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	Art Unit 2829	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *18 July 2011*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-19,22 and 24* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-19, 22, and 24* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *See Continuation Sheet*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

Continuation of Attachment(s) 2). Information Disclosure Statement(s) (PTO/SB/08), Paper No(s)/Mail Date :6/14/2011, 8/5/2011, 11/10/2011, 1/12/2012, 4/5/2012, 7/23/2012, 8/9/2012, 12/18/2012.

Attorney's Docket Number: 0020-5147PUS7

Filing Date: 9/14/2009

Claimed Domestic Priority:	7/29/1997 (08/902725 DIV)
	4/28/1999 (09/300315 DIV)
	12/10/1999 (09/458024 DIV)
	7/1/2003 (10/609402 DIV)
	2/8/2008 (12/028062 DIV)
Claimed Foreign Priority:	7/29/1996 (JP 08-198585)
	9/17/1996 (JP 08-244339)
	9/18/1996 (JP 08-245381)
	12/27/1996 (JP 08-359004)
	3/31/1997 (JP09-081010)

Applicant: Shimizu et al.

Examiner: Raj R. Gupta

DETAILED ACTION

This Office Action responds to the amendment and RCE filed on 7/18/2011.

Acknowledgment

1. The amendment filed on 7/18/2011, responding to the Office Action mailed on 3/16/2011, has been entered. The present Office Action is made with all the suggested amendments being fully considered. Accordingly, pending in this Office Action are **claims 1-19, 22, and 24**.

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 7/18/2011 has been entered.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. **Claims 1-3, 7, 9, 10, 12-14, 22, and 24** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Stinson (US 4992704)** in view of **Baretz et al. (US 6600175)** and **Furuyama et al. (US 5221984)**.

6. With regard to **claims 1 and 2**, Stinson teaches, in Figs 2-4, a light emitting device comprising: a mount (17), a plurality of light emitting chips (7, 8, 9) mounted on said mount in a recess (18) formed in said mount, and a transparent material (11) covering said light emitting chips.

7. Stinson does not explicitly teach said transparent material including a first region in the vicinity of at least one of said light emitting chips, and a second region in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic.

8. Baretz teaches, said transparent material (20, 11) including a first region (20) in the vicinity of at least one of said light emitting chips, and a second region (11) in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light (col 9, ln 5-10), wherein a concentration of said phosphor in said first region in said transparent material (concentration of phosphor in 20 is larger than 0, see col 9, ln 1-10) is larger than a concentration of said phosphor in said second region in said transparent material (concentration of phosphor in 11 is 0, see col 8, ln 60-65), wherein the main emission peak of said light emitting chips is within the range from 400 nm to

530 nm (450 nm, col 9, ln 12), “to allow for the generation of white light from a blue or ultraviolet emitting LED die,” (col 7, ln 30-35).

9. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson with the phosphor of Baretz to allow for the generation of white light from a blue or ultraviolet emitting LED die.

10. Stinson/Baretz do not explicitly teach that said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic.

11. Furuyama teaches that said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic (metalized ceramic, col 10, ln 50-55) to serve as, “a heat-discharging member,” (col 10, ln 54).

12. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz with the mount material of Furuyama to have the mount serve as a heat discharging member.

13. With regard to **claim 3**, Stinson teaches, in Figs 2-4, a light emitting device comprising: a mount (17), a plurality of light emitting chips (7, 8, 9) mounted on said mount in a recess (18) formed in said mount, and a transparent material (11) covering said light emitting chips.

14. Stinson does not explicitly teach said transparent material including a first region in the vicinity of at least one of said light emitting chips, and a second region in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second

region in said transparent material, wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

15. Baretz teaches, said transparent material (20, 11) including a first region (20) in the vicinity of at least one of said light emitting chips, and a second region (11) in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light (col 9, ln 5-10), wherein a concentration of said phosphor in said first region in said transparent material (concentration of phosphor in 20 is larger than 0, see col 9, ln 1-10) is larger than a concentration of said phosphor in said second region in said transparent material (concentration of phosphor in 11 is 0, see col 8, ln 60-65), wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm (450 nm, col 9, ln 12), "to allow for the generation of white light from a blue or ultraviolet emitting LED die," (col 7, ln 30-35).

16. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson with the phosphor of Baretz to allow for the generation of white light from a blue or ultraviolet emitting LED die.

17. Stinson/Baretz do not explicitly teach that a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

18. Furuyama teaches that a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm) (copper plate, col 10, ln 50-55, it is well known in the art that the thermal

conductivity of copper is 401 W/mK = 0.96 cal/(s)(cm^2)(°C/cm)) to serve as, "a heat-discharging member," (col 10, ln 54).

19. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz with the mount material of Furuyama to have the mount serve as a heat discharging member.

20. With regard to **claim 7**, Baretz teaches that said phosphor comprises two or more kinds of fluorescent materials (col 9, ln 10-30).

21. With regard to **claim 9**, Baretz teaches that said phosphor has a crystal structure (col 9, 10-30, it is inherent that all substances have a crystal structure, even if that structure is amorphous).

22. With regard to **claim 10**, Baretz teaches that said phosphor diffuses said light emitted from said light emitting chips (col 7, ln 5-20, it is clear to one of ordinary skill that absorbing and reemitting light would diffuse the light).

23. With regard to **claim 12**, Baretz teaches that said light emitting chips comprise InGaN (col 10, ln 20-27).

24. With regard to **claim 13**, Baretz teaches that said light emitting chips comprise a sapphire substrate (col 10, ln 36-40).

25. With regard to **claim 14**, Baretz teaches that said transparent material is selected from the group consisting of epoxy resin, urea resin, silicone resin and glass (epoxy resin, col 9, ln 25-30; glass melt, col 9, ln 65 - col 10, ln 5).

26. With regard to **claim 22**, Stinson teaches, in Figs 2-4, a light emitting device comprising: a mount (17), a plurality of light emitting chips (7, 8, 9) mounted on said mount, a plurality of

inner leads (20, 21, 22) separated from said mount, each inner lead being connected to one of said light emitting chips (clear in the figures), a transparent material (11) covering said light emitting chips.

27. Stinson does not explicitly teach said transparent material including a first region in the vicinity of at least one of said light emitting chips, and a second region in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic.

28. Baretz teaches, said transparent material (20, 11) including a first region (20) in the vicinity of at least one of said light emitting chips, and a second region (11) in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light (col 9, ln 5-10), wherein a concentration of said phosphor in said first region in said transparent material (concentration of phosphor in 20 is larger than 0, see col 9, ln 1-10) is larger than a concentration of said phosphor in said second region in said transparent material (concentration of phosphor in 11 is 0, see col 8, ln 60-65), wherein the main emission peak of said light emitting chips is within the range from 400 nm to

530 nm (450 nm, col 9, ln 12), "to allow for the generation of white light from a blue or ultraviolet emitting LED die," (col 7, ln 30-35).

29. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson with the phosphor of Baretz to allow for the generation of white light from a blue or ultraviolet emitting LED die.

30. Stinson/Baretz do not explicitly teach that said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic.

31. Furuyama teaches that said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin, and metalized ceramic (metalized ceramic, col 10, ln 50-55) to serve as, "a heat-discharging member," (col 10, ln 54).

32. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Sintson/Baretz with the mount material of Furuyama to have the mount serve as a heat discharging member.

33. With regard to **claim 24**, Stinson teaches, in Figs 2-4, a light emitting device comprising: a mount (17), a plurality of light emitting chips (7, 8, 9) mounted on said mount, a plurality of inner leads (20, 21, 22) separated from said mount, each inner lead being connected to one of said light emitting chips (clear in the figures), a transparent material (11) covering said light emitting chips.

34. Stinson does not explicitly teach said transparent material including a first region in the vicinity of at least one of said light emitting chips, and a second region in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength

different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

35. Baretz teaches, said transparent material (20, 11) including a first region (20) in the vicinity of at least one of said light emitting chips, and a second region (11) in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light (col 9, ln 5-10), wherein a concentration of said phosphor in said first region in said transparent material (concentration of phosphor in 20 is larger than 0, see col 9, ln 1-10) is larger than a concentration of said phosphor in said second region in said transparent material (concentration of phosphor in 11 is 0, see col 8, ln 60-65), wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm (450 nm, col 9, ln 12), "to allow for the generation of white light from a blue or ultraviolet emitting LED die," (col 7, ln 30-35).

36. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson with the phosphor of Baretz to allow for the generation of white light from a blue or ultraviolet emitting LED die.

37. Stinson/Baretz do not explicitly teach that a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

38. Furuyama teaches that a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm) (copper plate, col 10, ln 50-55, it is well known in the art that the thermal conductivity of copper is 401 W/mK = 0.96 cal/(s)(cm^2)(°C/cm)) to serve as, "a heat-discharging member," (col 10, ln 54).

39. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz with the mount material of Furuyama to have the mount serve as a heat discharging member.

40. **Claims 4-6 and 8** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Stinson (US 4992704)** in view of **Baretz et al. (US 6600175)** and **Furuyama et al. (US 5221984)** as applied to claim 1 above, and further in view of **Pinnow et al. (US 3699478)**.

41. With regard to **claim 4**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

42. Baretz also teaches that said light emitting chips emit a light having a spectrum with a peak in the range from 420 to 490 nm (450 nm, col 9, ln 12).

43. However, Stinson/Baretz/Furuyama do not explicitly teach that said phosphor emits light having a spectrum with a peak in the range from 510 to 600 nm and a tail continuing beyond 700 nm, and said spectrum of the light emitted from said phosphor and said spectrum of the light emitted from said light emitting chips overlap with each other to make a continuous combined spectrum.

44. Pinnow teaches, in Fig 1, that that said phosphor emits light having a spectrum (dotted line) with a peak in the range from 510 to 600 nm and a tail continuing beyond 700 nm (clear from the figure), and said spectrum of the light emitted from said phosphor and said spectrum of

the light emitted from said light emitting chips overlap with each other to make a continuous combined spectrum (clear from the figure) to produce, “a black and white image with a minimum of speckling,” (col 1, ln 32-35).

45. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the phosphor of Pinnow to minimize speckling.

46. With regard to **claim 5**, Pinnow teaches, in Fig 1, that said spectrum of the light emitted from said phosphor has a peak in the range from 530 to 570 nm and a tail continuing beyond 700 nm (clear from the figure).

47. With regard to **claim 6**, Baretz teaches that a color of said combined spectrum is white (col 7, ln 7-20).

48. With regard to **claim 8**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

49. However, Stinson/Baretz/Furuyama do not explicitly teach that said phosphor comprises an yttrium-aluminum-garnet fluorescent material containing Y and Al.

50. Pinnow teaches that said phosphor comprises an yttrium-aluminum-garnet fluorescent material containing Y and Al (col 1, ln 42-48) to produce, “a black and white image with a minimum of speckling,” (col 1, ln 32-35).

51. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the phosphor of Pinnow to minimize speckling.

52. **Claim 11** is rejected under 35 U.S.C. 103(a) as being unpatentable over **Stinson (US 4992704)** in view of **Baretz et al. (US 6600175)** and **Furuyama et al. (US 5221984)** as applied to claim 1 above, and further in view of **Scott (US 5594751)**.

53. Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

54. However, Stinson/Baretz/Furuyama do not explicitly teach that said light emitting chips comprise a light emitting layer of single quantum well or multi quantum well structure.

55. Scott teaches that light emitting chips comprising a light emitting layer of single quantum well or multi quantum well structure are, “conventional,” (col 3, ln 45-51).

56. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the conventional quantum well light emitting layer of Scott. See Supreme Court decision in KSR International Co. v. Teleflex Inc., 550 U.S. _, 82 YSPQ2d 1385 (2007).

57. **Claims 15-17** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Stinson (US 4992704)** in view of **Baretz et al. (US 6600175)** and **Furuyama et al. (US 5221984)** as applied to claim 1 above, and further in view of **Ogura (US 6015200)**.

58. With regard to **claim 15**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

59. However, Stinson/Baretz/Furuyama do not explicitly teach that said transparent material contains a dispersant.

60. Ogura teaches that said transparent material contains a dispersant (col 6, ln 20-35), "to provide an illuminating device of a high uniformity of the illumination intensity and a low electric power consumption, allowing easy compactization and cost reduction," (col 3, ln 50-55).

61. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the dispersant of Ogura to provide an illuminating device of a high uniformity of the illumination intensity and a low electric power consumption, allowing easy compactization and cost reduction.

62. With regard to **claim 16**, Ogura teaches that said dispersant is selected from the group consisting of barium titanate, titanium oxide, aluminum oxide and silicon dioxide (col 6, ln 20-35).

63. With regard to **claim 17**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

64. However, Stinson/Baretz/Furuyama do not explicitly teach that said transparent material contains a coloration agent.

65. Ogura teaches that said transparent material contains a coloration agent (col 6, ln 20-35), "to provide an illuminating device of a high uniformity of the illumination intensity and a low electric power consumption, allowing easy compactization and cost reduction," (col 3, ln 50-55).

66. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the coloration agent of Ogura to provide an illuminating device of a high uniformity of the illumination intensity and a low electric power consumption, allowing easy compactization and cost reduction.

67. **Claims 18 and 19** are rejected under 35 U.S.C. 103(a) as being unpatentable over **Stinson (US 4992704)** in view of **Baretz et al. (US 6600175)** and **Furuyama et al. (US 5221984)** as applied to claims 1 and 3 above, and further in view of **Otsuki (US 5801435)**.

68. With regard to **claim 18**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 1.

69. However, Stinson/Baretz/Furuyama do not explicitly teach that said mount is plated with silver, copper or gold.

70. Otsuki teaches that said mount is plated with silver, copper or gold (col 1, ln 30-35) so that, "the thermal or electrical conductivity between the heat radiator and the semiconductor chip can be improved," (col 1, ln 30-35).

71. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the mount plating of Otsuki so that the thermal or electrical conductivity between the heat radiator and the semiconductor chip can be improved.

72. With regard to **claim 19**, Stinson/Baretz/Furuyama teach most of the limitations of this claim as discussed above with regard to claim 3.

73. However, Stinson/Baretz/Furuyama do not explicitly teach that said mount is plated with silver, copper or gold.

74. Otsuki teaches that said mount is plated with silver, copper or gold (col 1, ln 30-35) so that, "the thermal or electrical conductivity between the heat radiator and the semiconductor chip can be improved," (col 1, ln 30-35).

75. Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to combine the light emitting device of Stinson/Baretz/Furuyama with the mount plating of Otsuki so that the thermal or electrical conductivity between the heat radiator and the semiconductor chip can be improved.

Response to Arguments

76. Applicant's arguments filed 7/18/2011 have been fully considered but they are not persuasive.

77. In response to applicant's argument that the references fail to show certain features of applicant's invention, it is noted that the features upon which applicant relies (i.e., that each of the first and second regions of the transparent material contain the phosphor) are not recited in the rejected claim(s). Although the claims are interpreted in light of the specification, limitations from the specification are not read into the claims. See *In re Van Geuns*, 988 F.2d 1181, 26 USPQ2d 1057 (Fed. Cir. 1993). In the instant case, the claimed limitations, as currently recited, are met by the prior art as set forth in the rejections.

Conclusion

78. All claims are drawn to the same invention claimed in the application prior to the entry of the submission under 37 CFR 1.114 and could have been finally rejected on the grounds and art of record in the next Office action if they had been entered in the application prior to entry under 37 CFR 1.114. Accordingly, **THIS ACTION IS MADE FINAL** even though it is a first action after the filing of a request for continued examination and the submission under 37 CFR 1.114. See MPEP § 706.07(b). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

79. A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

80. Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAJ R. GUPTA whose telephone number is (571)270-5707. The examiner can normally be reached on Monday-Thursday 9am-6pm.

81. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ha T. Nguyen can be reached on (571)272-1678. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

82. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/RAJ R GUPTA/
Examiner, Art Unit 2829
February 28, 2013

/HA TRAN T NGUYEN/
Supervisory Patent Examiner, Art Unit 2829

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	1	U.S. Office Action issued in co-pending Application No. 12/575,155, dated April 19, 2011.	

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1 Applicant's unique citation designation number. (optional) 2 Applicant is to place a check mark here if English language Translation is attached.

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U.S. PATENT DOCUMENTS

Examiner Initial *	Cite No.	Document Number: Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-3,560,649	02-02-1971	Anderson	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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NON PATENT LITERATURE DOCUMENTS

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	2	U.S. Office Action issued in co-pending U.S. application no. 12/689,681 on May 10, 2012.	

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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U.S. PATENT DOCUMENTS

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	1	US-3,623,887	11-30-1971	Saulnier	
	2	US-3,842,306	10-15-1974	Henderson et al.	
	3	US-5,640,216	06-17-1997	Hasegawa et al.	
	4	US-5,670,797	09-23-1997	Okazaki	
	5	US-5,818,677	10-06-1998	Kurematsu et al.	

FOREIGN PATENT DOCUMENTS

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Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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	6	U.S. Office Action issued in co-pending application 12/548,614 on June 27, 2011.	
	7	U.S. Office Action issued in co-pending application 12/689,681 on June 23, 2011.	

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	Art Unit
	RAJ GUPTA	2814

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
257	88, 89, 99	7/26/2010	RG
	updated search	3/10/2011	RG
	updated search	2/28/2013	RG

SEARCH NOTES

Search Notes	Date	Examiner
Inventor, Class, and Text Search in EAST	7/26/2010	RG
updated search	3/10/2011	RG
updated search	2/28/2013	RG

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

/RAJ R GUPTA/
Examiner.Art Unit 2829

Index of Claims	Application/Control No. 12559042	Applicant(s)/Patent Under Reexamination SHIMIZU ET AL.
	Examiner RAJ GUPTA	**Art Unit** 2814

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE									
Final	Original	07/27/2010	03/10/2011	02/28/2013							
	1	✓	✓	✓							
	2	✓	✓	✓							
	3	✓	✓	✓							
	4	✓	✓	✓							
	5	✓	✓	✓							
	6	✓	✓	✓							
	7	✓	✓	✓							
	8	✓	✓	✓							
	9	✓	✓	✓							
	10	✓	✓	✓							
	11	✓	✓	✓							
	12	✓	✓	✓							
	13	✓	✓	✓							
	14	✓	✓	✓							
	15	✓	✓	✓							
	16	✓	✓	✓							
	17	✓	✓	✓							
	18	✓	✓	✓							
	19	✓	✓	✓							
	20		✓	-							
	21		✓	-							
	22		✓	✓							
	23		✓	-							
	24		✓	✓							
	25		✓	-							

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	1	US-5,247,533	09-21-1993	Okazaki et al.	
	2	US-5,408,120	04-18-1995	Manabe et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country 3 Code	Number 4 Kind Code (if known) 5	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	3	JP	7-335942	12-22-1995	Nichia Chem Ind Ltd.		✔

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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PTO/SB/08b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Substitute for form 1449B/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	**Application Number**	12/559,042
	Filing Date	09-14-09
	First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)	Art Unit	2829
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Sheet 2 of 2	Attorney Docket Number	0020-5147PUS7

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	4	Singaporean Examination and Search Report issued on July 2, 2012 in counterpart Singapore Patent Application No. 201007151-2.	✔
	5	Singaporean Examination and Search Report issued on July 5, 2012 in counterpart Singapore Patent Application No. 201007150-4.	✔
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	1	US-2012/0132857 - A1	05-31-2012	Le Toquin	
	2	US-3,204,143	08-31-1965	Pritchard	
	3	US-3,882,502	05-06-1975	Peabody et al.	
	4	US-5,707,549	01-13-1998	Matsukiyo et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country 3 Code	Number 4 Kind Code (if known) 5	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	5	JP	2000-286455	10-13-2000	Nichia Chem. Ind. Ltd.		✔
	6	JP	48-39866	05-18-1973			☐
	7	JP	52-40959	10-15-1977			☐
	8	JP	53-43885	04-14-1978			☐
	9	JP	7-193281	07-28-1995	Mitsubishi Materials Corp.		✔
							☐

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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Sheet	2	of	2	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	10	"An Experimental Result of Packages Having Different Phosphors and Colloids", pp. 374-384.	
	11	"Measurement Service Report", prepared by Industrial Technology Research Institute in Taiwan, pp. 298-358, May 4, 2012.	
	12	E-mail correspondences sent from Dow Corning Toray Co., Ltd. to the requester of the cancellation action, September 28, 2011.	
	13	Phosphor Handbook, pp. 5-11, published December 25, 1987.	
	14	Request for Invalidation with Notification of Acceptance of Request for Invalidation of CN Patent No. 200610095837.4 issued on September 10, 2012 in a counterpart Chinese application.	
	15	US Office Action issued in copending US Application No. 12/575,155 on October 4, 2012.	
	16	US Office Action issued in copending US Application No. 12/689,681 on September 7, 2012.	
	17	US Office Action issued in copending US Application No. 12/947,470 on November 15, 2012.	
	18	US Office Action issued in copending US Application No. 13/210,027 on October 2, 2012.	

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number Number - Kind Code 2 (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2006/0067668 - A1	03-30-2006	KITA	
	2	US-2008/0128735 - A1	06-05-2008	YOO et al.	
	3	US-5,966,393 - A	10-12-1999	HIDE et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country 3 Code Number 4 Kind Code (if known) 5	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	4	JP 9-116225 - A	05-02-1997			✓

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449B/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	12/559,042
				Filing Date	09-14-09
				First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)				Art Unit	2829
				Examiner Name	Raj R. Gupta
Sheet	2	of	2	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
	5	U.S. Office Action, dated January 30, 2012, for U.S. Application No. 12/942,792.	
	6	U.S. Office Action, dated January 9, 2012, for U.S. Application No. 12/947,470.	
	7	U.S. Office Action, dated March 13, 2012, for U.S. Application No. 13/210,027.	

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	1	of	1

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Cite No. 1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	1	US Office Action issued in co-pending application no. 12/669,681 on December 5, 2011.	

Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants hereby submit an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☐ a. Copies of foreign patent documents, non-patent literature and other information.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

☑ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date

12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☐ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

The publication by Yao Go submitted herein was cited in the Request for Invalidation of Chinese Patent No. 03159595.2 submitted herein. Chinese Patent No. 03159595.2 is a counterpart foreign application of the present US application. The Request for Invalidation submitted herein was submitted to the Chinese Patent Office by a third party and then the Chinese Patent Office dispatched a Notification of Acceptance of Request for Invalidation, submitted herein, for informing the fact that a third party submitted a Request for Invalidation.

A concise explanation regarding publication by Yao Go and the Request for Invalidation is submitted herein, as follows. The publication by Yao Go cited in the Request for Invalidation is alleged to describe that a crystal structure of the garnet will have a defect and a light emitting characteristics will be suddenly changed if all Y is replaced with Gd. This concise explanation corresponds to a portion of the publication by Yao Go cited in the Request for Invalidation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

All references discussed and cited in the US Office Action of co-pending Appl. No. 12/575,155 submitted herein were previously submitted to USPTO.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS.

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this

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IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of this statement.

V. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☑ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed <u>before</u> the mailing date of a Final Office Action or <u>before</u> the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(c)(1)). cet

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VI. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: November 10, 2011

Respectfully submitted,

By ______________________

D. Richard Anderson
Registration No.: 40439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

cet

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication
- ☐ Foreign Search Report
- ☐ Fee
- ☑ Other: (1) Request for Invalidation with Notification of Acceptance of Request for Invalidation of Chinese Patent No. 03159595.2 dispatched on August 10, 2011.
  (2) Office Action issued in co-pending US Appl. No. 12/575,155 on September 30, 2011.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

Sheet 1 of 1

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	Office Action issued in co-pending US Appl. No. 12/575,155 on September 30, 2011.	☐
	2	Request for Invalidation with Notification of Acceptance of Request for Invalidation of Chinese Patent No. 03159595.2 dispatched on August 10, 2011.	☐
	3	Yao Go et al., Synthesis and Luminescence Gallium Nitride LED Blue Light Conversion Materials, ACTA PHYSICO-CHIMICA SINICA, Vol.19, No.3, March 2003, p226 – 229.	☑
			☐
			☐
			☐
			☐
			☐
			☐
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Examiner Signature	/Raj R Gupta/	Date Considered	03/01/2013

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1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

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Substitute for form 1449A/PTO

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Sheet 1 of 2

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Art Unit	2829
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Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number Number - Kind Code 2 (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2006/0197098 - A1	09-07-2006	Aihara	
	2	US-3,875,473 - A	04-01-1975	Lebailly	
	3	US-4,849,630 - A	07-18-1989	Fukai et al.	
	4	US-5,334,855	08-02-1994	Moyer et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country 3 Code Number 4 Kind Code (if known) 5	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	5	EP 1681728 - A1	07-19-2006			☐
	6	WO 2005/109532 - A1	11-17-2005			☐
	7	WO 2010/023840 - A1	03-04-2010			☐
	8	GB 2098002 - A	11-10-1982			☐
	9	JP 7-183581 - A	07-21-1995			☑
						☐

Examiner Signature		Date Considered	

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wt

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

Sheet 2 of 2

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	10	European Search Report for European Application No. 10158422.5 dated December 19, 2012.	
	11	European Search Report for European Application No. 10158429.0 dated December 19, 2012.	
	12	European Search Report for European Application No. 10158437.3 dated January 3, 2013.	
	13	European Search Report for European Application No. 10158449.8 dated January 3, 2013.	
	14	European Search Report for European Application No. 10158455.5 dated January 3, 2013.	
	15	US Office Action for US Application No. 12/689,681, dated February 5, 2013.	
	16	US Office Action for US Application No. 12/947,470, dated January 14, 2013.	

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

ct

Electronic Patent Application Fee Transmittal

Application Number:	12559042
Filing Date:	14-Sep-2009
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Filer:	Corina E. Tanasa/David Ofori-Amanfo
Attorney Docket Number:	0020-5147PUS7

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	15286497
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Corina E. Tanasa/David Ofori-Amanfo
Filer Authorized By:	Corina E. Tanasa
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	18-MAR-2013
Filing Date:	14-SEP-2009
Time Stamp:	16:59:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$180
RAM confirmation Number	6108
Deposit Account	022448
Authorized User	ANDERSON, RICHARD D.

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Foreign Reference	EP-1681728-A1.pdf	7116556 a8a38315b6f467524c5ce6d877d3b80ffc0d2d99	no	59
Warnings:					
Information:					
2	Foreign Reference	WO-2005-109532-A1.pdf	1834240 3f1068182125647eec4160b3e11060efa15a4848	no	22
Warnings:					
Information:					
3	Foreign Reference	WO-2010-023840-A1.pdf	3406405 38578abb63c08ec3ea4c3e5d2b97da55ad1a0cd8	no	35
Warnings:					
Information:					
4	Foreign Reference	GB-2098002-A.pdf	428107 a5b34632fe5bc545eb2f687b8f68b89b041b1a11	no	5
Warnings:					
Information:					
5	Foreign Reference	JP-7-183581-A.pdf	2595188 d300052a2c4031f2147c0a902eb1ac3d921ee754	no	12
Warnings:					
Information:					
6	Foreign Reference	JP-5-152609-A.pdf	1569209 ec99a1ae0177cf640167e55a55f63fb75854d0db	no	8
Warnings:					
Information:					
7	Non Patent Literature	E-SR-101584225.pdf	653340 dc842d9bc7f5f16a707efd443e0cdec7cb139593	no	8
Warnings:					
Information:					
8	Non Patent Literature	E-SR-101584290.pdf	649517 b479620896209f398905d3ca514048bda37b19fe	no	9
Warnings:					
Information:					

9	Non Patent Literature	E-SR-101584373.pdf	708340 48d7b805ff9645dacba505067373a84e18823e65	no	8
Warnings:					
Information:					
10	Non Patent Literature	E-SR-101584498.pdf	726053 0b4771bdc07d5d09186df9675640ecab30f84c6d	no	9
Warnings:					
Information:					
11	Non Patent Literature	E-SR-101584555.pdf	629668 5346390342d8a64a18c254e8f3a48f81b274a540	no	8
Warnings:					
Information:					
12	Non Patent Literature	US-OA-12689681.pdf	406355 de19a0f3c4e9ceda342e63de6a61bb1360d11d57	no	10
Warnings:					
Information:					
13	Non Patent Literature	US-OA-12847470.pdf	381619 7848301d10d4fe17a7d078ea6bbb792c4d919a30	no	12
Warnings:					
Information:					
14		2013-03-18-IDSTransmittal-0020-5147PUS7.pdf	480670 57fb4c93c652d0f48e85fe123c86a1b0dc57c13f	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Transmittal Letter	2	7
Information Disclosure Statement (IDS) Form (SB08)	8	9

Warnings:					
Information:					
15	Fee Worksheet (SB06)	fee-info.pdf	30388 e8c160008f31ff43a1f3aafb072e6e150438c691	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	21615655		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 681 728 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
19.07.2006 Bulletin 2006/29

(21) Application number: **04792476.6**

(22) Date of filing: **15.10.2004**

(51) Int Cl.:
H01L 33/00 *(1974.07)*

(86) International application number:
PCT/JP2004/015259

(87) International publication number:
WO 2005/038935 (28.04.2005 Gazette 2005/17)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR

(30) Priority: **15.10.2003 JP 2003355399**
17.03.2004 JP 2004075577
05.04.2004 JP 2004110817
01.06.2004 JP 2004163491

(71) Applicant: **Nichia Corporation**
Anan-shi, Tokushima 774-8601 (JP)

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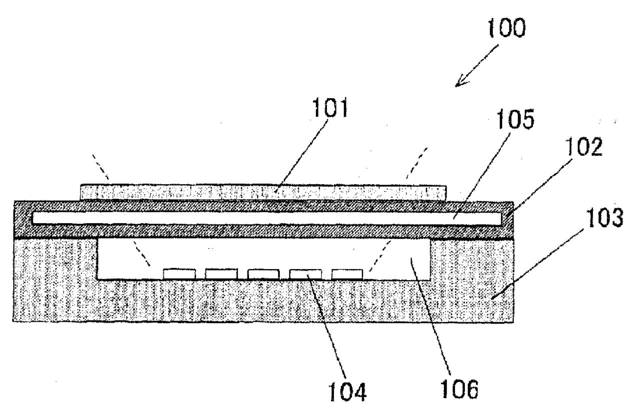
  c/o NICHIA CORPORATION
  Anan-shi Tokushima 7748601 (JP)
- **TAMAKI, Hiroto**
  c/o NICHIA CORPORATION
  Anan-shi Tokushima 7748601 (JP)
- **TAKEICHI, Junji**
  c/o NICHIA CORPORATION
  Anan-shi Tokushima 7748601 (JP)

(74) Representative: **Joly, Jean-Jacques et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cédex 07 (FR)

(54) **LIGHT-EMITTING DEVICE**

(57) A light emitting device comprises a light emitting element, and a light conversion member including a phosphor material that is capable of absorbing light emitted from the light emitting element at least partially and emitting light in different wavelength. The light emitting device further comprises a heat dissipation member in a side where the light conversion member as viewed from the light emitting element.

FIG.1



EP 1 681 728 A1

Description

Technical Field

[0001] The present invention relates to a light emitting device with a light emitting element such as laser diode (LD) and light emitting diode (LED) mounted therein. More particularly, the present invention relates to a light emitting element with a light emitting element and a phosphor material that absorbs light from the light emitting element as excitation light and emits luminescent radiation of different wavelength. Moreover, the present invention relates to a heat dissipation member used against heat dissipation of a semiconductor light emitting element or a semiconductor photoreceptor element, or a heat generating element such as semiconductor device, and to a semiconductor apparatus having this heat dissipation member.

Background Art

[0002] A lighting apparatus with a number of light emitting diodes mounted on a conductive plate is proposed as a lighting apparatus employing light emitting diodes. For example, in a lighting apparatus shown in Patent Document 1, a cooling member is connected to a conductive plate in a side where light emitting diodes are not mounted, thus, heat dissipation of light emitting diodes is accelerated to provide a lighting apparatus that can emit high power light. In addition, in order to further improve heat dissipation, a cooling fluid is circulated in the cooling member.

[0003] Furthermore, in a vacuum fluorescence tube shown in Patent Document 2, for example, an anode of a conductor with a phosphor layer coated thereon, and a cathode that opposes to the anode are provided in a vacuum case. This vacuum fluorescence tube is used as a vacuum fluorescence tube of a light source for a facsimile. In this case, a part of the anode with the phosphor layer coated thereon extends outwardly of the vacuum case as an extending portion. The extending portion serves as a cooling portion that is exposed to the outside air. In this fluorescent tube, the anode with the phosphor layer coated thereon is made of a heat conductive metal such that the aforementioned cooling portion aids heat dissipation, thus, heat generation of the phosphor layer that is coated can be reduced. Accordingly, in the vacuum fluorescence tube, deterioration of the phosphor is prevented, thus, it is possible to improve luminous efficiency and to maintain high-brightness light emission.

[0004] Typical cooling means in a heat sink used against heat dissipation of a heating element, such as semiconductor device is divided into two types, one is passive cooling means, and another one is active cooling means. In the former, heat of the heat generating element is dissipated by using a heat sink with a high heat capacity. In the latte, heat is taken away by flowing cooling water in a heat sink with a heat generating element mounted thereon. In recent years, since semiconductor apparatuses are required to further increase output or brightness, active cooling means is preferably employed in terms of cooling efficiency.

[0005] In semiconductor apparatuses employing passive cooling means, for example, an infrared semiconductor laser array has been provided one to several tens watts (W) of light output. The semiconductor laser array refers to an array that has a plurality of resonators arranged on a single semiconductor crystal, or to an array that has respective resonators arranged on a plurality of separated semiconductor crystals.

[0006] Moreover, a semiconductor laser array with stack structure has been provided several tens to several kilowatts (W) of light output. Active cooling means is employed in this type of semiconductor apparatus with stack structure. For example, Patent Document 3 has been proposed a technique that cools directly under a semiconductor laser array with a water path provided in a heat sink. A plurality of very small holes that are formed by narrowing the water path are provided in the water path so as to spray pressurized fluid toward directly below heat generating elements. The fluid is vigorously sprayed toward directly below the semiconductor laser array, thus, it is possible to improve heat transmission efficiency. In the structure of this semiconductor apparatus, the water path is designed such that the fluid is incident upon the heat dissipation surface of the heat generating element such as semiconductor laser at substantially right angle.

Patent Document 1: Japanese Laid-Open Patent Publication TOKUHYOU No. 2002-544673
Patent Document 2: Japanese Laid-Open Patent Publication TOKUKAI No. SHO 59-161966
Patent Document 3: Japanese Laid-Open Patent Publication TOKUKAI No. HEI 8-139479

Disclosure of Invention

[0007] Generally, it is known that the light conversion efficiency of a phosphor contained in a light conversion member reduces as the ambient temperature of the phosphor rises. In order to solve the above problem, the aforementioned techniques are devised as a method for eliminating an external heat generation factor of the light conversion member in a light emitting device. That is, a mount substrate of light emitting diode is cooled, or the cooling portion is provided in a side of terminal with a phosphor coated thereon that the phosphor is not coated, to eliminate heat of the light conversion member that is externally received.

[0008] On the other hand, a high-pressure mercury lamp, or the like, can be given as an example of light source that is conventionally selected to excite a phosphor. However, the high-pressure mercury lamp generates a large amount of heat, and additionally has visible light spectrum. Accordingly, a filter, or the like, is required to pass only ultraviolet light. The applicant et al. reported that a nitride semiconductor element emitted high power ultraviolet light (JJAP Vol.41 (2002) L1434-1436), and devised that this type of light emitting element would be used as an excitation light source for a phosphor material. This could provide less heat generation, and obtain only high power ultraviolet light spectrum without filter, or the like, as compared with light sources for excitation in the ultraviolet region that are conventionally selected. Accordingly, the external heat generation factor of a light conversion member in a light emitting device became almost negligible.

[0009] However, even in the case where this type of semiconductor light emitting element with a short wavelength spectrum is employed as an excitation light source for phosphor, the heat generation of a light conversion member caused by the spectrum is negligible, but it is found that the heat generation of a phosphor is not negligible. That is, the phosphor that is exposed to high energy excitation light provides self-heat generation due to loss of stokes hotoluminescence of phosphor (hereinafter, referred to as "stokes loss"). In this case, dissimilarly to the temperature rise of the whole light conversion member due to heat that is externally applied, the phosphor the light conversion member reduces its light conversion efficiency due to its own heat generation.
Therefore, it is a fist object of the present invention to suppress self-heat generation of a phosphor and to prevent deterioration of a light conversion member, and to improve the luminous efficiency of phosphor to provide a high power light emitting device.

[0010] Moreover, in the aforementioned semiconductor laser shown as an exemplary active cooling system, or the like, the water path is designed such that fluid is incident upon the heat dissipation surface of the heat generating element at substantially right angle, thus, there is a feature that frictional resistance in an internal wall surface of the heat sink is reduced to approaches zero. In this case, a kind of coating is formed in a part where the fluid (cooling medium) and the heat dissipation surface are in contact with each other. The cooling water is vigorously sprayed toward the coating in the direction perpendicular to the coating surface to break the coating. This is aimed at efficiently improving cooling efficiency.

[0011] However, as for a surface emission type light emitting device, such as LED and surface emission type laser, when mounted in a matrix shape, it performs its function well. That is, when a plurality of surface emission type light emitting devices, such as LED and surface emission type laser, are combined to provide a high power light emitting device, it is necessary to mount a plurality of surface emission type light emitting devices in a matrix shape. Since each surface emission type light emitting device is a heat generating element, it is necessary to highly efficiently cool each surface emission type light emitting device. On the other hand, in the case where the aforementioned water path structure is employed, since a part where the fluid (cooling medium) is sprayed in the direction perpendicular to the heat dissipation surface is limited, forming a water path for each surface emission type light emitting device makes the water path complicated. Accordingly, it is difficult to mount surface emission type light emitting devices at high density.
Therefore, it is a second object of the present invention to provide a heat sink (heat dissipation member) with sufficient cooling function, and a semiconductor apparatus having this heat sink, more particularly even in the case where a heat dissipation surface and a flowing direction of fluid (cooling medium) have an arrangement relationship where they are parallel to each other, or in the case where one or more heat generating element is mounted on a surface parallel to a flowing direction of fluid (cooling medium), to provide a heat sink with sufficient cooling function, and a semiconductor apparatus having this heat sink.

[0012] A light emitting device of one aspect of the present invention comprises a light emitting element, a light conversion member including a phosphor material that is capable of absorbing light emitted from the light emitting element at least partially and emitting light in different wavelength, and a heat dissipation member that is located in a side where the light conversion member is provided as viewed from the light emitting element. In this construction, heat of a phosphor is efficiently dissipated as compared with a conventional light emitting device, thus, self-heat generation of the phosphor is suppressed, and deterioration of the phosphor is prevented. Accordingly, the light conversion efficiency of the phosphor is improved. Therefore, it is possible to provide a light emitting device with higher power.

[0013] In addition, the heat dissipation member has a flow path of a refrigerant. In this case, heat is efficiently dissipated by the heat dissipation member, thus, the heat dissipation characteristics of the phosphor material is further improved. Therefore, it is possible to provide a light emitting device with higher power.

[0014] In addition, the heat dissipation member includes a pair of an inlet for admission of the refrigerant and an outlet for ejection of the refrigerant that is circulated through the flow path. In this construction, the refrigerant is circulated to the heat dissipation member, thus, the heat dissipation characteristics of the light emitting device is improved. Therefore, it is possible to provide a higher power light emitting device.

[0015] In addition, the heat dissipation member is formed of a material that passes at least light from the light emitting element, or a material that passes light from both the light emitting element and the light conversion member. In this case, in the case where the light conversion member is provided not only on a main surface in a side where light is observed on the heat dissipation member, and additionally the light conversion member can be provided also on a main surface in a side where light from the light emitting element is incident.

[0016] In addition, the heat dissipation member is formed of two plate-shaped members that form the flow path for flowing cooling fluid between them, and a plurality of the light emitting elements are mounted to be two-dimensionally arranged on a main surface of the heat dissipation member, wherein a plurality of protruding portions are formed in the surface of the plate-shaped member inside the flow path, and at least some of the plurality of protruding portions are formed such that their centers are located between the light emitting elements and a substantially central part of the light emitting element. In this construction, self-heat generation of the phosphor is suppressed, and deterioration of the phosphor is prevented. Accordingly, the light conversion efficiency of the phosphor is improved. Additionally, deterioration of light output due to self-heat generation of the light emitting element. Therefore, it is possible to mount a plurality of light emitting elements at high density. This can provide a light emitting device with higher power.

[0017] A light emitting device of another aspect of the present invention comprises a light emitting element, a light conversion member including a phosphor material that is capable of absorbing light emitted from the light emitting element at least partially and emitting light in different wavelength, and a heat dissipation member, wherein the heat dissipation member having a flow path of a refrigerant includes a first heat dissipation member that has a first flow path in a side where the light emitting element is mounted, and a second heat dissipation member that has a second flow path in a side where light from the light emitting element is incident, the second heat dissipation member including the light conversion member. In this construction, heat of a phosphor is efficiently dissipated as compared with a conventional light emitting device, thus, self-heat generation of the phosphor is suppressed, and deterioration of the phosphor is prevented. Accordingly, the light conversion efficiency of the phosphor is improved. Therefore, it is possible to provide a light emitting device with higher power.

[0018] In addition, the flow path includes a third flow path that connects the first flow path to the second flow path. In this construction, the refrigerant provided to the light emitting device can flow in the first and second flow paths in the directions where they are parallel to each other, thus, heat is dissipated by a single heat dissipation system. Therefore, it is possible to simplify the structure of the heat dissipation member of the light emitting device.

[0019] In addition, each or one of the first and second heat dissipation members includes a pair of an inlet for admission of the and an outlet for ejection of the refrigerant that is circulated through the flow path. In this construction, the refrigerant is continuously admitted and ejected, thus, the heat dissipation characteristics of the light emitting device is improved. Therefore, it is possible to provide a higher power light emitting device.

[0020] In addition, the first heat dissipation member, an insulating member, a supporting substrate, and the second heat dissipation member are laminated. In this construction, it is possible to provide a light emitting device with simple structure and excellent heat dissipation characteristics.

[0021] In addition, the heat dissipation member has the inlet or outlet in at least one of main surface sides, and the insulating member and the supporting substrate have through holes that form parts of the third flow path. In this construction, a pair of inlet and outlet can be formed in a direction of principle plane of the light emitting device, thus, it is possible to circulate the refrigerant in a direction that does not affect the optical characteristics of the light emitting device.

[0022] In addition, a conductive member that contains at least one element selected the group consisting of Au, Ag, and Al is coated on at least one of main surfaces of the insulating member. In this construction, it is possible to easily supply electric power to the light emitting element.

[0023] In addition, one electrode of the light emitting element is electrically connected to the conductive member that is coated on the at least one of main surfaces of the insulating member via a conductive wire, another electrode is electrically connected to the first heat dissipation member. In this construction, it is possible to supply electric power to the light emitting element.

[0024] In addition, the second heat dissipation member is formed of a material that passes at least light from the light emitting element, or a material that passes light from both the light emitting element and the light conversion member. In this case, in the case where the light conversion member is provided on the second heat dissipation member, the light conversion member can be provided not only on a main surface in a side where light is observe but on a main surface in a side where light from the light emitting element is incident.

[0025] In addition, each or one of the first and the second heat dissipation members is formed of two plate-shaped members that form the flow path for flowing cooling fluid between them, and a plurality of the light emitting elements are mounted to be two-dimensionally arranged on a main surface of the first heat dissipation member, wherein a plurality of protruding portions are formed in the surface of the plate-shaped member inside the flow path, and at least some of the plurality of protruding portions are formed such that their centers are located between the light emitting elements and a substantially central part of the light emitting element. In this construction, self-heat generation of the phosphor is suppressed, and deterioration of the phosphor is prevented. Accordingly, the light conversion efficiency of the phosphor is improved. Additionally, deterioration of light output due to self-heat generation of the light emitting element. Therefore, it is possible to mount a plurality of light emitting elements at high density. This can provide a light emitting device with higher power.

[0026] A light emitting device of still another aspect of the present invention comprises a heat dissipation member that is formed of two plate-shaped members that form a flow path for flowing cooling fluid between them, and a plurality of light emitting elements that are mounted to be two-dimensionally arranged on a main surface of the heat dissipation member, wherein a plurality of protruding portions are formed in the surface of the plate-shaped member inside the flow path, and at least some of the plurality of protruding portions are formed such that their centers are located between the light emitting elements and a substantially central part of the light emitting element. In this construction, heat density in the surface of plate-shaped member inside the flow path decreases. Accordingly, deterioration of light output due to self-heat generation of the light emitting element, thus, it is possible to a plurality of mount heat generating elements at high density. This can provide a high power light emitting device.

[0027] In addition, the plurality of protruding portions are arranged in the bended manner such that line segments that successively connect the protruding portions closest to each other repeatedly change their direction from an inlet part to an outlet part of the flow path. In this construction, heat density in this part can be reduced, thus, it is possible to suppress heat distribution and to provide high efficient cooling. Therefore, the light emitting device can provide higher power.

[0028] In addition, at least some of the plurality of protruding portions are formed such that their centers are located between the light emitting elements. In this construction, it is possible to suppress heat distribution produced inside the light emitting device and to provide high efficient cooling. Therefore, the light emitting device can provide higher power.

[0029] In addition, the plurality of protruding portions are located at a substantially central part of and in the peripheries of the corners of the light emitting element. In this construction, the heat distribution produced inside the light emitting element, and the heat distribution produced by heat interference between the light emitting elements are suppressed. Accordingly, it is possible to efficiently dissipate heat. Thus, it is possible to provide high efficient cooling. This can provide a light emitting device with higher power.

[0030] In addition, a metal material containing Au coats an attachment surface of the plate-shaped members. In this construction, it is possible improve bonding characteristics of the plate-shaped members that are bonded with each other. Therefore, it is possible to provide a light emitting device with higher reliability.

Brief Description of Drawings

[0031] Fig. 1 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;

Fig. 2 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;
Fig. 3 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;
Fig. 4 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;
Fig. 5 shows characteristics of examples according to the present invention and a comparative example;
Fig. 6 is a schematic perspective view of a light emitting device according to one embodiment of the present invention, with parts of the light emitting device is broken away for the purpose of illustration;
Fig. 7 is a perspective view schematically showing components of a light emittin device according to one embodiment of the present invention;
Fig. 8 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;
Fig. 9 is a cross-sectional view schematically showing a light emitting device according to one embodiment of the present invention;
Fig. 10 is a perspective view schematically showing a component according to one embodiment of the present invention;
Fig. 11 is a cross-sectional view schematically showing the structure of a semiconductor apparatus according to the present invention;
Fig. 12 is a perspective view schematically showing the structure of the semiconductor apparatus according to the present invention, with a metal cap and so on removed for the purpose of illustration;
Fig. 13 is a cross-sectional view schematically showing the structure of a heat sink according to the present invention;
Figs. 14(a) to (c) are a perspective view, a plan view, and a cross-sectional view schematically showing a first plate-shaped member according to one example of the present invention, respectively;
Figs. 15(a) to (c) are a perspective view, a plan view, and a cross-sectional view schematically showing a second plate-shaped member according to one example of the present invention, respectively;

Figs. 16(a) and (b) are a plan view, and a cross-sectional views showing the plate-shaped members combined with each other shown in Figs. 4 and 5;

Figs. 17(a) and (b) are a plan view, and a cross-sectional view schematically showing arrangement between a semiconductor element and a protruding portion inside a flow path;

Fig. 18 is a view showing a unit module of light source apparatus with an LED light source according to the embodiment of the present invention;

Fig. 19 is a view showing a unit module of light source apparatus with an LED light source according to the embodiment of the present invention;

Fig. 20 is a view showing an ultra high power unit module of light source apparatus with an LED light source according to the embodiment of the present invention;

Fig. 21 is a view showing an ultra high power unit module of light source apparatus with an LED light source according to the embodiment of the present invention;

Fig. 22 shows relative comparison between the IL characteristics of an LED device with active cooling means according to the embodiment of the present invention, and an LED device with passive cooling means;

Fig. 23 shows the IL characteristics of a high brightness LED light source according to the embodiment of the present invention;

Fig. 24 is comparison of deterioration curves predicted based on between CW-ACC drive tests of a high brightness LED light source according to the embodiment of the present invention, and an LED 1 device with passive cooling means;

Fig. 25 is comparison of deterioration curves predicted based on between CW-ACC drive tests of a high brightness LED light source according to the embodiment of the present invention, and the LED 1 device with passive cooling means;

Figs. 26(a) to (c) show pressure contours of examples according to the present invention and a comparative example;

Fig. 27 shows a relationship between the minimum temperature of heat dissipation member of each of the light emitting devices of example according to the present invention and a comparative example, and the flow rate of fluid;

Fig. 28 shows a relationship between the minimum temperature of heat dissipation member of each of the light emitting devices of example according to the present invention and a comparative example, and the flow rate of fluid; and

Fig. 29 shows a relationship between the thermal resistance of heat dissipation member of each of the light emitting devices of example according to the present invention and a comparative example, and the flow rate of fluid;

Explanation of Reference Letters or Numerals

[0032] 1, 10 Heat Generating Element
2 First Plate-Shaped Member
3 Second Plate-Shaped Member
100, 200, 300, 400 Light emitting device
101, 201, 301, 401 Light Conversion Member
102, 202, 302, 402 Heat Dissipation Member
103 Support Member
104 Semiconductor Light Emitting Element
105 Flow Path
106, 111 Recessed Portion
107 Insulating Member
108 Supporting substrate
109 Second Heat Dissipation Member
109a, 115a First Plate-Shaped Member
109d, 115b Second Plate-Shaped Member
110 Third Flow Path
112 First Flow Path
113 Second Flow Path
114 O-Ring
115 First Heat Dissipation Member
116 Conductive Member
302 Transparent Member

Best Mode for Carrying out the Invention

[0033] Preferred embodiments according to the present invention are described with reference to the drawings. It should be appreciated, however, that the embodiments described below are illustrations of a light emitting device to give a concrete form to technical ideas of the invention, and a light emitting device of the invention are not specifically limited to description below. Additionally, the sizes and the arrangement relationships of the members in each of drawings are occasionally shown larger exaggeratingly for ease of explanation.

FIRST EMBODIMENT

[0034] A light emitting device of a first embodiment of the present invention comprises a light emitting element, a light conversion member including a phosphor material that is capable of absorbing light emitted from the light emitting element at least partially and emitting light in different wavelength, and a heat dissipation member that is located in a side where the light conversion member is provided as viewed from the light emitting element. That is, the light emitting device according to the present invention comprises a semiconductor light emitting element, a light conversion member, and a heat dissipation member, thus, the heat dissipation member aids heat dissipation from the light conversion member containing a phosphor. Accordingly, even in the case where the phosphor is exposed to high power excitation light, since self-heat generation of the phosphor can be suppressed, and deterioration of the phosphor can be prevented, the output of light emitting device does not deteriorate. Therefore, high power light, such as white range light, can be emitted.

[0035] The light emitting device according to this embodiment has the light conversion member located in an orientation where light from the light emitting element is incident, and the heat dissipation member that is located adjacent to or inside the light conversion member and aids heat dissipation from the light conversion member. The heat dissipation member preferably has a flow path that is located in a side where the light conversion member is located. The flow path can contain a refrigerant for aiding heat dissipation from the light conversion member. Accordingly, self-heat generation of the phosphor that is exposed to high power and high energy excitation light can be suppressed. In this specification, hereinafter, the "refrigerant" refers to a thermal cooling medium, such as cooling water, cooling gas and inert liquid with a low boiling point, or a solid thermal gradient medium, such as Peltier element. When the refrigerant is circulated, heat dissipation is improved, however, the present invention is not limited to this circulation.

[0036] The light conversion member in this embodiment is spaced at a certain interval away from the light emitting element, and is located in the orientation where light from the light emitting element is incident. This can reduce that heat from the light emitting element affects the phosphor as compared with a conventional light emitting device with a light conversion member that directly coats a light emitting element. Particularly, in this embodiment, it is preferable that the light conversion member is applied to the heat dissipation member that is configured to be a flat grid shape to form openings. Alternatively, the heat dissipation member may be configured to be a three-dimensional grid shape inside the light conversion member. In other words, it is preferable that the heat dissipation member extends in a net shape inside the light conversion member. In this case, the light conversion member is formed in at least one surface where light from the light emitting element is incident, or where light is observed.

[0037] In addition, it is preferable that a periphery part of the light conversion member that is applied in a flat shape as viewed from a side where light is observed is thermally connected to a support member on which the semiconductor light emitting element is mounted. The term "thermally connected" refers to direct connection between components, or connection between components through a high thermal conductive material other than them, and to connection here heat can be conducted well between connected components. In this case, heat is efficiently conducted from a central part of the light conversion member that is applied in a flat shape toward the periphery part as viewed from a side where light is observed. Accordingly, the heat dissipation characteristics of the phosphor material are further improved. Therefore, it is possible to provide a light emitting device with higher power.

[0038] The heat dissipation member according to this embodiment preferably has a light reflection member that reflects light from the light emitting element or light with a wavelength converted by the light conversion member in a prescribed direction. More specifically, the light conversion member, the light reflection member, and the heat dissipation member are laminated in order from the side where light from the semiconductor light emitting element is incident. On the other hand, in the case where the heat dissipation member is a transparent material, the light conversion member, the heat dissipation member, and the light reflection member may be laminated in order from the side where light from the semiconductor light emitting element is incident. A white metal, such as Al, Ag and Rh, or an alloy containing at least one element of them can be given as a material of the light reflection member. Alternatively, the heat dissipation member may be formed of the metal material with high reflectivity such that the heat dissipation member directly reflects light emitted from the light conversion member.

[0039] Plating, sputtering, screen printing, or the like, can be employed as a method that directly applies the aforementioned light reflection member to the heat dissipation member. The light reflection member according to this embodiment is not limited to be directly applied to the heat dissipation member, but may be a separate member that is formed of the aforementioned material, and provided adjacent to the heat dissipation member.

[0040] At least a part of the heat dissipation member can be a curved surface that is radiated with light from the semiconductor light emitting element and directs light from the phosphor material in a prescribed direction. The curved surface can have various shapes such as paraboloid and ellipsoi so as to tight from the semiconductor light emitting element and to direct it in a prescribed direction.

[0041] The heat dissipation member according to this embodiment includes at least a pair of an inlet for admission of the refrigerant and an outlet for ejection of the refrigerant that is circulated through the flow path of the heat dissipation member on an outer wall of the heat dissipation member. The location, number, and shape of the outlet or inlet are selected to improve a cooling effect in consideration of the size, and shape of the light emitting device, and are not limited to this form. Thus, the refrigerant can be circulated in the heat dissipation member.

[0042] In the case where the density of light incident on the light conversion member is not less than 3 W/cm^2, and the light emitting device is driven by applying a electric current, the temperature of the light conversion member is set to not more than 200°C, preferably to 120°C, and more preferably to 100°C. Accordingly, the heat dissipation characteristics of the light emitting device are improved, therefore, it is possible to provide a high power light emitting device. The components according to this embodiment will be described.

[0043] The components of the light emitting device according to the first embodiment are now described.

(Heat Dissipation Member)

The heat dissipation member in the light emitting device according to this embodiment is a member that aids heat dissipation from the light conversion member, particularly the phosphor material contained in the light conversion member, in a side where light from the light emitting element is incident. In addition, the heat dissipation member is a member that is thermally connected to the support member on which the light emitting element is mounted, and dissipates heat from the light conversion member toward the support member. Hereinafter, the heat dissipation member is described in more detail.

[0044] The heat dissipation member according to this embodiment refers to a member that is provided with the light conversion member containing the phosphor directly thereon or so as to sandwich a high thermal conductive material other than them between them, and conducts heat generated from the phosphor externally of the light emitting device. In addition, the heat dissipation member according to this embodiment also refers to a member that has the flow path for cooling the phosphor, is provided with the light conversion member containing the phosphor thereon, and conducts heat generated from the phosphor externally of the light conversion member. It is preferable that the heat dissipation member is thermally connected to the support member on which the light emitting element is mounted. Additionally, it is preferable to provide an air cooling fan, a solid thermal gradient medium, such as Peltier element, and a heat dissipation block on the back surface of the light conversion member or in the periphery of the heat dissipation member. This allows heat of the light conversion member or heat dissipation member to be effectively externally conducted.

[0045] It is preferable that the heat dissipation member is formed of a material that can pass at least light from the light emitting element, or a material that can pass light from both the light emitting element and the light conversion member. In this case, the light conversion member can be provided on at least one of a main surface in a side where light is observed on the heat dissipation member, and a main surface in a side where light from the light emitting element is incident. Although the light conversion member is connected directly to the heat dissipation member, the light conversion member is not limited to this form. Needless to say, the light conversion member may be mounted to the heat dissipation member so as to sandwich a transparent member other than them between them. In addition, the shape of the light conversion member in a side where light is observed can have a lens shape in consideration of the optical characteristics of light from the light emitting device. Alternatively, the light emitting device can have an optical member for control of directivity of light from the light emitting device such as convex lens and concave lens in addition to the light conversion member. Additionally, the heat dissipation member may have a transparent part that contains the phosphor to serve as the light conversion member. Moreover, the flow path of the refrigerant for cooling the phosphor may be formed inside the light conversion member.

[0046] In this embodiment, the flow path of the refrigerant is applicable to a path closed or opened externally of the light emitting device. As one example of the heat dissipation member having an opened flow path, the heat dissipation member can have a flat plate that is made of a metal, such as copper and aluminum, and is provided with a flow path for passing the refrigerant therethrough. In the case where the heat dissipation member has a transparent part, a transparent resin, a quartz material, or the like, is selected as a material of the transparent part. In addition, in order to circulate the refrigerant through the heat dissipation, the heat dissipation member has at least one pair of an inlet and an outlet on its outer wall surface. The heat dissipation member can have a plurality of plate-shaped members at least one of which has a groove or asperities, and through holes as the inlet and outlet. For example, the heat dissipation member has a first plate-shaped member that has a groove or a recessed shape and through holes as the inlet and outlet, and a second plate-shaped member. Surfaces of the first and second plate-shaped members that are opposed to each other are bonded, thus, the flow path of the heat dissipation member can be formed. Needless to say, in this embodiment, the shape of the heat dissipation is not limited to an illustrated shape. In the first plate-shaped member as a portion of the heat dissipation member, for example, a recessed portion is formed so as to be gradually wider and then narrower from the location where one of openings (inlet or outlet) is formed to other opening. This allows the refrigerant to smoothly circulate through the flow path. Additionally, it is preferable that small grooves or asperities are formed on an inner wall surface of the recessed portion. This increases the contact area between the refrigerant and the heat dissipation member, and thus can improve a heat dissipation effect for the light emitting device.

[0047] As one example of the heat dissipation member having a closed flow path, the heat dissipation member can have a heat pipe that is made of a metal, such as copper and aluminum, and is provided with the refrigerant sealed therein. Particularly, in another embodiment, a heat pipe is a metal tube that is made of a metal, such as copper and aluminum, in which a hydraulic fluid for conveying heat, such as water, CFCs, alternative CFCs and Fluorinert, is sealed, for example. In this case, the hydraulic fluid is heated and evaporated in a heat input part (high temperature part), and the evaporated liquid moves and then liquefied in a heat dissipation part (lower temperature side). The liquefied hydraulic fluid is moved back to the heat input portion by capillary phenomenon, thus this cycle is repeated. Accordingly, a heat conveying member with high heat conductivity can be provided.

[0048] The heat dissipation member can have various types of shapes and sizes in consideration of a heat dissipation direction and a heat dissipation effect. For example, asperities are formed on the inner wall surface of the flow path that is opposed to a surface on which the light conversion member is provided. This increases the contact area between the aforementioned inner wall surface and the refrigerant as compared with the case where asperities are not formed, and thus can improve the heat dissipation characteristics from the light conversion member. In addition, in the heat dissipation member that is configured to be a grid shape to form openings, a plurality of through holes can be formed in a plate-shaped material of heat dissipation member so as to be arranged in a matrix shape. Alternatively, the through holes can be formed by connecting a plurality of line materials in a grid shape.

[0049] In the heat dissipation member formed in a plate shape, it is preferable that the minimum distance d (mm) between its surface that is opposed to the light conversion member and the inner wall surface of the flow path satisfies the following Equation.

$$0.05 < d < (C/800) \qquad \text{(Equation 1)}$$

where C is the thermal conductivity in W/mK of a plate-shaped member that composes the heat dissipation member. For example, in the case where the heat dissipation member is formed of oxygen-free copper, it is preferable that d (mm) is set within the following range.

$$0.05 < d < 0.5 \qquad \text{(Equation 2)}$$

Additionally, in the case where the heat dissipation member is formed of ceramics, such as alumina and aluminum nitride, it is preferable that d (mm) is set within the following range.

$$0.05 < d < 0.25 \qquad \text{(Equation 3)}$$

If the value of d is lager than the upper limit, the thermal resistance of the heat dissipation member becomes too large. In this case, thermal interference between the light emitting elements adjacent to each other becomes remarkable. Accordingly, the light emitting elements cannot be mounted at high density. If the value of d is smaller than the lower limit, the plate-shaped member cannot be easily processed.

[0050] (Support Member)

The support member according to this embodiment refers to a member that is provided with the light emitting element mounted thereon and a conductive wire for supplying electric power to the light emitting element, and serves as a support member for supporting other components to achieve sufficient mechanical strength of the light emitting device. The supporting member can have various sizes in consideration of heat dissipation characteristics, the output of light emitting device and so on, and have various shapes in consideration of the shape of light emitting device. In addition, in order to control distribution of light, a reflector may be provided on a part of the support member.

[0051] For example, the support member may have inclined walls that reflect light from the light emitting element in the direction where the light is observed. The inclined walls can be formed as inner walls of a tapered recessed portion and the inner walls are opposed to the light emitting element mounted in the recessed portion. In addition, a reflector layer may be formed on the inclined walls for excellent reflection of the light from the light emitting element. In order to efficiently dissipate heat conducted from the light emitting element toward the heat dissipation member side, the support member preferably has high heat conductivity. Ceramics, copper, aluminum, and a phosphor bronze plate can be given to employ each of them alone as preferable examples of materials with high heat conductivity. In addition, it is preferably used with silver or palladium that is coated on its surface, or with metal plating such as silver and gold, solder plating or the like that is performed on its surface.

[0052] (Semiconductor Light Emitting Element)

The semiconductor light emitting element refers to a laser diode or light emitting diode that emits light of a wavelength capable of exciting the phosphor. The semiconductor light emitting element preferably has a light emitting layer that emits light of a particular wavelength capable of efficiently exciting the phosphor.

[0053] Various semiconductors, such as BN, SiC, ZnSe, GaN, InGaN, InAlGaN, AlGaN, BAlGaN, and BInAlGaN can be given as materials of the semiconductor light emitting element. Si, Zn, and so on, can be included in these elements as impurity elements and serve as the center of light emission. Particularly, a nitride semiconductor (e.g., a nitride semiconductor containing A and Ga, or a nitride semiconductor containing In and Ga, i.e., $In_xAl_yGa_{1-x-y}N$ $0 \leq x$, $0 \leq y$, $x + y \leq 1$) can be given as a material of light emitting layer that can efficiently emit light with a short wavelength from the visible region to the ultraviolet region capable of efficiently exciting the phosphor. B can also be employed as a III group element in addition to the material. P or As can be substituted as a part of N of a V group element. Homo structure, hetero structure, or double-hetero structure with MIS junction, PIN junction, pn junction, or the like, can be employed as the structure of semiconductor. Various light-emission wavelengths can be selected depending on and mixed crystal ratios of semiconductor layer. The semiconductor layer can have a single- or multi-quantum-well structure provided with thin layer(s) for quantum effect.

[0054] Any method known as a growth method of nitride semiconductor can be employed as a growth method of the aforementioned nitride semiconductor. For example, MOVPE (Metal-Organic Chemical Vapor Deposition), MOCVD (Metallorganic Chemical Vapor Deposition), HVPE (Hydride Chemical Vapor Deposition), MBE (molecular beam epitaxy method), and so on, can be given as examples, but the present invention is not limited to them. In particular, since MOCVD can provide excellent crystallinity, it is preferably employed.

[0055] In the case where a nitride semiconductor is employed, a material, such as sapphire, spinel, SiC, Si, and ZnO, is preferably employed as a substrate for semiconductor. In order to form a nitride semiconductor with excellent crystallinity in quantity, it is preferable to employ a sapphire substrate. A semiconductor can be formed on the sapphire substrate by using MOCVD. A buffer layer of GaN, AlN, GaAlN, and so on, is formed on the sapphire substrate, and then a nitride semiconductor with pn junction is formed thereon.

[0056] The following double-hetero structure can be given as an example of the light emitting element employing a nitride semiconductor with pn junction. In the double-hetero structure, a first contact layer formed of n-type gallium nitride, a first cladding layer formed of n-type aluminum-nitride gallium, an active layer formed of indium-gallium nitride, a second cladding layer formed of p-type aluminum-nitride gallium, and a second contact layer formed of p-type gallium nitride are successively laminated on the buffer layer.

[0057] A nitride semiconductor has n-type conductivity in the state where an impurity is not doped. In the case where a desired n-type nitride semiconductor is formed to improve luminous efficiency or to achieve other purpose, it is preferable that Si, Ge, Se, Te, C, or the like, is doped, if necessary. On the other hand, in the case where a p-type nitride semiconductor is formed, Zn, Mg, Be, Ca, Sr, Ba, or the like, which are p-type dopants, are doped. Even if a nitride compound semiconductor is doped with a p-type dopant, this can hardly provide p-type conductivity. Accordingly, after a p-type dopant is doped, it is preferable to achieve low resistance by heating with a furnace, plasma irradiation, and so on.

[0058] In order to widely provide a current supplied to the light emitting element over the whole area of the p-type semiconductor, a diffusion electrode is formed on the p-type semiconductor. In addition, p-side and n-side pad electrodes that are connected to conductive members such as bumps or conductive wires are formed on the diffusion electrode and the n-type semiconductor, respectively.

[0059] The p-side and n-side pad electrodes of the semiconductor light emitting element are electrically connected to conductive members or heat dissipation members that are provided in an insulating member through the conductive wires. Alternatively, the semiconductor light emitting element is mounted in a flip chip mounting manner through solder or bump, and is electrically connected to the support member or the heat dissipation members.

[0060] An electrode formation surface of the nitride semiconductor layer construction can be a light-outgoing surface. Alternatively, a side of the substrate on which nitride semiconductor layers are laminated can be a light-outgoing surface. In the case where the side of the substrate on which nitride semiconductor layers are laminated can be a light-outgoing surface, a protection film is preferably formed except surfaces where the electrodes of the nitride semiconductor element are formed. In this case, the electrodes that are formed on the nitride semiconductor layer construction are connected to external terminals, and so on, through metallizing layers (bumps) in a facedown manner. In the case where the side of the substrate is a light-outgoing surface, light-outgoing efficiency is improved.

[0061] The nitride semiconductor element according to the present invention may have a structure where a p-type nitride semiconductor layer, an active layer, and an n-type nitride semiconductor layer are formed so as to sandwich a conductive layer and a p-electrode between the p-type nitride semiconductor layer and a supporting substrate, and an n-electrode was formed on the n-type nitride semiconductor layer. This nitride semiconductor element has an opposed electrode configuration where the p-electrode and n-electrode are opposed to each other so as to sandwich the nitride semiconductor layers. In the case of this nitride semiconductor element, the n-electrode side is a light-outgoing surface. Since, in a nitride semiconductor (in particular, GaN group semiconductor), an n-type layer has low resistance, the size of n-electrode can be reduced. Since reduction of the size of n-electrode reduces an area where light is cut off, the light outgoing efficiency can be improved.

[0062] Moreover, a semiconductor light emitting element according to another form is composed only of nitride semiconductor layers, and has opposed electrodes that are formed on the upper and lower surfaces of the semiconductor layer construction. This type of semiconductor light emitting element with opposed electrodes is secured with a conductive adhesive agent such that one of the electrodes opposes the heat dissipation member according to this embodiment. The insulating member according to this embodiment is provided with the conductive member that is coated from a surface opposing the support member to a recessed portion thereof. Accordingly, the one of the electrodes of the light emitting element is electrically connected to the heat dissipation member, and the other electrode is connected to the aforementioned conductive member through a conductive wire. For example, silver paste, or a eutectic material, such as Au-Sn, and Ag-Sn, can be given as a material of the conductive adhesive agent.

[0063] A formation method of this type of semiconductor light emitting element with opposed electrodes is now described. First, after n-type and p-type nitride semiconductor layers are laminated similarly to the aforementioned semiconductor element, an insulating film is formed on a p-electrode as a first electrode and the p-type nitride semiconductor layer except the p-electrode. On the other hand, a supporting substrate is prepared to be attached on this semiconductor layer construction. Specifically, Cu-W, Cu-Mo, AlN, Si, SiC, and so on, can be given as materials of the supporting substrate. A structure with an intimate-contact layer, a barrier layer and a eutectic layer is preferably employed for an attachment interface. For example, metal layers, such as Ti-Pt-Au and Ti-Pt-AuSn are formed. These types of metal layers are alloyed, and compose a conductive layer in the following process.

[0064] Subsequently, a surface of the supporting substrate where the metal layers is formed and a surface of the nitride semiconductor layer construction are opposed to each other, and heat is applied thereto while pressing them. Then, a different material substrate is removed by irradiation of an excimer laser from a different material substrate side, or grinding. After that, an outer periphery part is etched by RIE, or the like, to form the nitride semiconductor element, thus, the nitride semiconductor element with the outer periphery part being removed is obtained. In addition, asperities may be formed (dimple processing) on an exposed surface of the nitride semiconductor by RIE, or the like, to improve light-outgoing efficiency. The cross-sectional shape of the asperities can be a mesa shape, an inverse mesa shape, and so on. The plan shape can be an island shape, a grid shape, a rectangular shape, a circular shape, polygonal shape, and so on. Finally, an n-electrode as a second electrode is formed on an exposed surface of the aforementioned nitride semiconductor layer construction. Ti/Al/Ni/Au, and W/Al/WPt/Au can be given as examples of a material of the electrode.

[0065] (Light Conversion Member)

A phosphor applicable to the present invention a material that absorbs a part of light from the light emitting element and emits luminescent radiation of a wavelength different from the absorbed light. Particularly, the phosphor employed in this embodiment is excited by at least light emitted from the semiconductor light emitting element, and emits luminescent radiation of a converted wavelength. The phosphor and a binding agent that binds this phosphor compose the light conversion member. The binding agent can be composed of a transparent resin such as epoxy resin, or a transparent inorganic material produced from a silicone resin or metal alkoxide with high light-resistance as an original material by a sol-gel method, for example. The light conversion member can be applied on the heat dissipation member by various methods, such as screen printing, ink-jet application, potting, and mimeograph printing. In addition, the phosphor may be contained in a transparent heat dissipation member. The phosphor that can be contained in the light conversion member according to this embodiment is now described.

[0066] <Aluminum Garnet Group Phosphor>

The aluminum garnet group phosphor employed in this embodiment is a phosphor that contains Al, at least one element selected from the group consisting of Y, Lu, Sc, La, Gd, Tb, Eu, and Sm, and least one element selected from the group consisting of Ga and In, and is activated by at least one element selected from the group consisting of rare earth elements. This aluminum garnet group phosphor is excited by visible light or ultraviolet rays emitted from an LED chip, and emits radiation.

[0067] $YAlO_3$:Ce, $Y_3Al_5O_{12}$:Ce, $Y_4Al_2O_9$:Ce, $(Y_{0.8}Gd_{0.2})_3Al_5O_{12}$:Ce, $Y_3(Al_{0.8}Ga_{0.2})_5O_{12}$:Ce, $Tb_{2.95}Ce_{0.05}Al_5O_{12}$, $Y_{2.90}Ce_{0.05}Tb_{0.05}Al_5O_{12}$, $Y_{2.94}Ce_{0.05}Pr_{0.01}Al_5O_{12}$, and $Y_{2.90}Ce_{0.05}Pr_{0.05}Al_5O_{12}$ can be given as the example. Particularly, in this embodiment, two kinds of yttrium aluminum oxide group phosphors (yttrium-aluminum-garnet phosphors (hereinafter, occasionally referred to as "YAG group phophors")) with different compositions that contain Y and are activated by Ce or Pr can be employed. Particularly, in use for high luminance and for a long time, it is preferable that $(Re_{1-x}Sm_x)_3(Al_{1-y}Ga_y)_5O_{12}$:Ce (where, $0 \le x \le 1$, $0 \le y \le 1$, and Re represents at least one element selected from the group consisting of Y, Gd, and La), or the like, is employed.

[0068] Since the phosphor of $(Re_{1-x}Sm_x)_3(Al_{1-y}Ga_y)_5O_{12}$:Ce has a garnet structure, it has heat, light, and moisture resistances, and its peak of excitation spectrum can be near 470 nm. In addition, the light emission peak is near 530nm, and it is possible to provide broad emission spectrum with foot extending to 720 nm.

[0069] In the light emitting device according to present invention, two or more kinds of phosphors may be mixed. That is, as for the aforementioned YAG phosphor, the wavelength components of RGB can be increased by mixing two or more kinds of phosphors of $(Re_{1-x}Sm_x)_3(Al_{1-y}Ga_y)_5O_{12}$:Ce with different Al, Ga, Y, La, and Gd, or different content of Sm. At present, light emitting elements have unevenness in their light-emission wavelengths. Accordingly, adjustment of mixture of two or more kinds of phosphors can achieve desired white range light, or the like. Specifically, adjusting the amount of phosphor with a different chromaticity point depending on the light-emission wavelength of light emitting element can provide light emission of arbitrary point on the chromaticity diagram on the line connected between the phosphor and the light emitting element.

[0070] When blue group light emitted from the light emitting element using a nitride group compound semiconductor as a light emitting layer is mixed with green group light and red group light emitted from a phosphor with yellow body color for absorption of the blue light, it is possible to provide desired white range light-emission color display. In the light emitting device, in order to provide this color mixture, particles or bulk of the phosphor may be included in various resins, such as epoxy resin, acrylic resin and silicone resin, or transparent inorganic substance such as silicon oxide and aluminum oxide. The resin or the substance includin the phosphor can be formed in a dot shape or a film shape to be thin to the extent that light from the light emitting element passes depending on various applications. Arbitrary color tone such as electric bulb color including white can be provided by adjusting the ratio between the phosphor and the transparent inorganic substance, or by selecting the light-emission wavelength of light emitting element.

[0071] In addition, when two or more kinds of phosphors are disposed in a certain order in the direction of light incident from the light emitting element, it is possible to provide a light emitting device capable of efficiently emitting light. That is, for example, when layers are laminated on the light emitting element with a reflective member, it is possible to effectively use the reflected light; one layer is a color converting member containing a phosphor capable of absorbing light in long wavelength side and emitting light with long wavelength, and other layer is a color converting member capable of absorbing light in wavelength side longer than that and emitting light with longer wavelength.

[0072] In use of a YAG phosphor, even in the case where the phosphor is located to be in contact with or close to a light emitting element with irradiation illuminance (Ee) = not less than 0.1 $W \cdot cm^{-2}$ and not more than 1000 $W \cdot cm^{-2}$, it is possible to provide a light emitting device with effective and sufficient resistance.

[0073] Since a YAG group phosphor that is activated by cerium and can emit luminescent radiation of green group light, used in this embodiment, has garnet structure, it has heat, light, and moisture resistance, and its peak of excitation spectrum can be near 420 nm to 470 nm. In addition, the light emission peak wavelength λp is near 510 nm, and provides broad emission spectrum with foot extending to near 700 nm. On the other hand, since a YAG group phosphor, which is an yttrium aluminum oxide group phosphor activated by cerium and can emit luminescent radiation of red group light, used in this embodiment, also has garnet structure, it has heat, light, and moisture resistance, and its peak of excitation spectrum can be near 420 nm to 470 nm. In addition, the light emission peak wavelength λp is near 600 nm, and provides broad emission spectrum with foot extending to near 750 nm.

[0074] In the composition of YAG group phosphor with garnet structure, substituting Ga for a part of Al shifts the emission spectrum toward the short wavelength side. Substituting Gd and/or La for a part of Y in the composition shifts the emission spectrum toward the long wavelength side. Thus, varying composition can continuously adjust the luminescent color. Accordingly, the ideal condition of conversion into white range light emission by using blue group light emission of nitride semiconductor is provided by continuous variation of intensity in the long wavelength side by composition ratio of Gd, and so on. When the substitution of Y is less than twenty percent, the green component increases and the red component reduces. On the other hand, when it is not less than eighty percent, the red component increases but luminance sharply reduces. In addition, similarly to the excitation absorption spectrum, in the composition of YAG group phosphor with garnet structure, substituting Ga for a part of Al shifts the excitation absorption spectrum toward the short wavelength side. Substituting Gd and/or La for a part of Y in the composition shifts the excitation absorption spectrum toward the long wavelength side. It is preferable that the peak wavelength of the excitation absorption spectrum of YAG group phosphor is in the short wavelength side relative to the peak wavelength of the emission spectrum of light emitting element. In this construction, when a current supplied to a light emitting element increases, the peak wavelength of the excitation absorption spectrum substantially agrees with the peak wavelength of the emission spectrum of light emitting element. Accordingly, it is possible to provide a light emitting device in which occurrence of chromaticity deviation is kept in check without reduction of excitation efficiency of phosphor.

[0075] The aluminum garnet group phosphor can be produced as follows. First, as for the phosphor, an oxide or a compound, which easily becomes into an oxide at high temperature, is employed as a material of Y, Gd, Ce, La, Al, Sm, Pt, Tb, and Ga, thus, the material is obtained by sufficiently mixing them at the stoichiometric ratio. Alternatively, a mixed material is obtained by mixing a coprecipitated oxide with an aluminum oxide and a gallium oxide; the coprecipitated oxide is obtained by burning a material obtained by coprecipitating solution, in which a rare earth element of Y, Gd, Ce, La, Sm, Pr, and Tb are dissolved in acid, with an oxalic acid at the stoichiometric ratio. After mixing the mixed material and an appropriate amount of fluoride such as ammonium fluoride as flux, inserting them in to a crucible, then burning them at temperature 1350°C to 1450°C in air for 2 hours to 5 hours, as a result, a burned material can be obtained. Next, the burned material is crushed in water by a ball mill. Then washing, separating, drying it, finally sifting it through a sieve, the photo-luminescent phosphor can be obtained. Additionally, a method for producing a phosphor according to another embodiment includes two steps for burning. In a first burning step, mixture composed of mixed material, in which a material of phosphor is and flux is burned in the air or a weak reducing atmosphere. In a second burning step, the mixture is burned in a reducing atmosphere. The weak reducing atmosphere refers to a reducing atmosphere with low effect including at least a necessary amount of oxygen to form a desired phosphor from a mixed material in the reaction process. The first burning process is performed in this weak reducing atmosphere until desired structure formation of the phosphor is completed, thus, it is possible to prevent a phosphor from turning to black, and light-absorption efficiency from reducing. The reducing atmosphere in the second burning process refers to a reducing atmosphere with high effect stronger than the weak reducing atmosphere. In the case of two steps for burning as discussed above, a phosphor with high absorption efficiency of excitation wavelength is obtained. Accordingly, when a light emitting device is formed by using the phosphor formed as discussed above, the amount of phosphor necessary for obtaining desired color tone can be reduced. Therefore, it is possible to provide a light emitting device with high light-outgoing efficiency.

[0076] Two or more kinds of aluminum garnet group phosphors activated by cerium with different compositions may be mixed or be independently located for use. In the case where the phosphors are independently located, it is preferable that they are located in the order from a light emitting element of a phosphor, which absorbs the light and emits luminescent radiation in the shorter wavelength side, and a phosphor, which absorbs the light and emits luminescent radiation in the wavelength side longer than that. This allows them to efficiently absorb the light and emits luminescent radiation.

[0077] The combination of an aluminum garnet group phosphor, typically such as an yttrium-aluminum-garnet phosphor and a lutetium-aluminum-garnet group phosphor, and a phosphor capable of emitting luminescent radiation of red group light, particularly, a nitride phosphor, can be used as the phosphor used in this embodiment. These YAG group phosphor and nitride phosphor can be mixed and included in the light conversion member, or may be separately included in a plurality of layers which compose the light conversion member. Hereinafter, each phosphor will be described.

<Lutetium-Aluminum-Garnet Group hosphor>

[0078] The lutetium-aluminum-garnet group phosphor is a phosphor represented the general formula $(Lu_{1-a-b}R_aM_b)_3(Al_{1-c}Ga_c)_5O_{12}$ (where R represents at least one element of rare earth elements necessary to include Ce; M is at least one element selected the group consisting of Sc, Y, La and Ga; and $0.0001 \leq a \leq 0.5$, $0 \leq b \leq 0.5$, $0.0001 \leq a + b < 1$, $0 \leq c \leq 0.8$). For example, the lutetium-aluminum-garnet group phosphor can be phosphors represented by the composition formulas $(Lu_{0.99}Ce_{0.01})_3Al_5O_{12}$, $(Lu_{0.90}Ce_{0.10})_3Al_5O_{12}$, and $(Lu_{0.99}Ce_{0.01})_3(Al_{0.5}Ga_{0.5})_5O_{12}$.

[0079] The lutetium-aluminum-garnet group phosphor (hereinafter, occasionally referred to as a "LAG group phosphor") can be produced as follows. A lutetium compound, a compound of rare earth element R, a compound of rare earth element M, an aluminum compound, and a gallium compound are used as phosphor materials. The compounds are measured so as to satisfy the ratio of the aforementioned general formula, respectively. Subsequently, these phosphor materials are mixed, or mixed additionally with a flux to obtain a material mixture. This material mixture is filled in a crucible, and is burned at a temperature 1100 to 1650°C in a reducing atmosphere. After cooled, it is dispersed, thus, the phosphor according to the present invention represented by the aforementioned general formula is obtained.

[0080] An oxide or a compound such as carbonate and hydroxide, which becomes into an oxide by thermal decomposition, is preferably used as a phosphor material. A coprecipitated material, which contains all of, or some of metallic elements composing the phosphor, can be used as a phosphor material. For example, the coprecipitated material can be obtained by adding an aqueous solution of alkali, carbonate, or the like, to an aqueous solution containing these elements, but it may be used after drying or thermal decomposition. Fluoride, borate, or the like, is preferably used as the flux. It is added within the range 0.01 to 1.0 by weight relative to 100 of the phosphor material by weight. It is preferable that the burning is performed in a reducing atmosphere where cerium as an activation agent is not oxidized. It is more preferable that the burning is performed in a mixed-gas atmosphere of hydrogen and nitrogen with a hydrogen concentration of not more than 3.0% by volume. It is preferable that the burning is performed at a temperature of 1200 to 1600°C to obtain a phosphor with a target center particle size. A temperature of 1300 to 1500°C is more preferable.

[0081] In the aforementioned general formula, R is an activation agent, and is at least one element of rare earth elements necessary to include Ce. Specifically, the rare earth elements are Ce, La, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lr. R can includes only Ce, but, may includes Ce and at least one element of rare earth elements other than Ce. The reason is that the rare earth elements other than Ce serve as coactivation agents. R preferably includes not less than 70 mol% of Ce relative to the total amount of R. The value a (the amount of R) is preferably $0.0001 \leq a \leq 0.5$. If the value a is less than 0.0001, the luminance decreases. On the other hand, the value a is more than 0.5, the luminance decreases due to concentration quenching. It is more preferable $0.001 \leq a \leq 0.4$, and most preferably $0.005 \leq a \leq 0.2$. The value b (the amount of M) is preferably $0 \leq b \leq 0.5$, more preferably $0 \leq b \leq 0.4$, and most preferably $0 \leq b \leq 0.3$. For example, in the case M is Y, if the value b is more than 0.5, the luminance decreases in long wavelength ultraviolet rays to short wavelength visible light, particularly in 360 to 410 nm. The value c (the amount of Ga) is preferably $0 \leq c \leq 0.8$, more preferably $0 \leq c \leq 0.5$, and most preferably $0 \leq c \leq 0.3$. If the value c is more than, the light-emission wavelength shifts toward short wavelength side, and the luminance decreases.

[0082] It is preferable that the center particle size of LAG group phosphor is within a range 1 to 100 μm, more preferably within a range 5 to 50 μm, and most preferably within a range 5 to 15 μm. A phosphor with center particle size of less than 1 μm tends to form aggregate. The phosphor with the particle size within a range 5 to 10 μm has a high light absorption coefficient, and a high conversion efficiency, and aids formation of the light conversion member. The phosphor having the particle size with excellent optical features is contained, thus, the mass-producibility of light emitting device is improved. It is preferable that the content of the phosphor with the above center particle size is high. It is preferable that its content is 20 to 50%. Employing the phosphor with less variation of the particle size can further reduce variation of the color. Accordingly, the light emitting device with an excellent color tone can be provided.

[0083] Since the lutetium-aluminum-garnet group phosphor is efficiently excited by ultraviolet rays or visible light of a wavelength range between 300 nm and 550 nm and emits luminescent radiation, it can be effectively used as the phosphor contained in the light conversion member. In addition, in the case
where two or more kinds of LAG group phosphors with different composition formulas are employed, or the LAG group phosphor is employed together with other kind of phosphor, the color of light emission of the light emitting device can be varied. A conventional light emitting device mixes blue range light emitted by a semiconductor light emitting element with yellow range luminescent radiation by a phosphor that absorbs the emitted light, and emits whitish mixed light. Accordingly, since light from the light emitting element partially passes for utilization, this type of apparatuses has advantages that can simplify its structure and easily improves its output. On the other hand, since the above light emitting device emits light consisting of mixed two colors, its color rendering is not sufficient. Therefore, improvement is required. The light emitting device that emits white range mixed light by employing the LAG group phosphor can improve color rendering as compared with such a conventional light emitting device. Additionally, since the LAG group phosphor has excellent temperature characteristics as compared with the YAG group phosphor, it is possible to provide a light emitting device that less deteriorates and has less color difference.

[0084] <Nitride Group Phosphor>

The phosphor used in the present invention can be a nitride group phosphor that contains N, at least one element selected from the group consisting of Be, Mg, Ca, Sr, Ba and Zn, and at least one element selected from the group consisting of C, Si, Ge, Sn, Ti, Zr and Hf, and is activated by at least one element selected from the group consisting rare-earth elements. In the present invention, the nitride group phosphor refers to a phosphor that absorbs visible light and ultraviolet rays emitted from an LED chip, and luminescent radiation by the YAG group phosphor, and thus is excited and emits luminescent radiation. For example, the following examples can be given: $Sr_2Si_5N_8$:Eu, Pr; $Ba_2Si_5N_8$:Eu, Pr; $Mg_2Si_5N_8$:Eu, Pr; $Zn_2Si_5N_8$:Eu, Pr; $SrSi_7N_{10}$:Eu, Pr; $BaSi_7N_{10}$:Eu, Ce; $MgSi_7N_{10}$:Eu, Ce; $ZnSi_7N_{10}$:Eu, Ce; $Sr_2Ge_5N_8$:Eu, Ce; $Ba_2Ge_5N_8$:Eu, Pr; $Mg_2Ge_5N_8$:Eu, Pr; $Zn_2Ge_5N_8$:Eu, Pr; $SrGe_7N_{10}$:Eu, Ce; $BaGe_7N_{10}$:Eu, Pr; $MgGe_7N_{10}$:Eu, Pr; $ZnGe_7N_{10}$:Eu, Ce; $Sr_{1.8}Ca_{0.2}Si_5N_8$:Eu, Pr; $Ba_{1.8}Ca_{0.2}Si_5N_8$:Eu, Ce; $Mg_{1.8}Ca_{0.2}Si_5N_8$:Eu, Pr; $Zn_{1.8}Ca_{0.2}Si_5N_8$:Eu, Ce; $Sr_{0.8}Ca_{0.2}Si_7N_{10}$:Eu, La; $Ba_{0.8}Ca_{0.2}Si_7N_{10}$:Eu, La; $Mg_{0.8}Ca_{0.2}Si_7N_{10}$:Eu, Nd; $Zn_{0.8}Ca_{0.2}Si_7N_{10}$:Eu, Nd; $Sr_{0.8}Ca_{0.2}Ge_7N_{10}$:Eu, Tb; $Ba_{0.8}Ca_{0.2}Ge_7N_{10}$:Eu, Tb; $Mg_{0.8}Ca_{0.2}Ge_7N_{10}$:Eu, Pr; $Zn_{0.8}Ca_{0.2}Ge_7N_{10}$:Eu, Pr; $Sr_{0.8}Ca_{0.2}Si_6GeN_{10}$:Eu, Pr; $Ba_{0.8}Ca_{0.2}Si_6GeN_{10}$:Eu, Pr; $Mg_{0.8}Ca_{0.2}Si_6GeN_{10}$:Eu, Y; $Zn_{0.8}Ca_{0.2}Si_6GeN_{10}$:Eu, Y; $Sr_2Si_5N_8$:Pr; $Ba_2Si_5N_8$:Pr; $Sr_2Si_5N_8$:Tb; $BaGe_7N_{10}$:Ce; or the like. However, the present invention is not limited to these examples. It is preferable that at least one element selected from the group consisting of Y, La, Ce, Pr, Nd, Gd, Tb, Dy, Ho, Er, and Lu is included as the rare earth element contained in the nitride phosphor. But, R, Sc, Sm, Tm, or Yb may be included. These rare-earth elements are mixed in the material as single substance, oxide, imide, amide, or other states. When Mn is employed, the particle size can be large. Accordingly, it is possible to improve the luminance.

[0085] Particularly, this phosphor can be Mn-added Sr-Ca-Si-N:Eu; Ca-Si-N:Eu; Sr-Si-N:Eu; Sr-Ca-Si-O-N:Eu; Ca-Si-O-N:Eu; and Sr-Si-O-N:Eu group silicon nitride. The basic component elements of this phosphor is represented by general formulas $L_XSi_YN_{(2/3X+4/3Y)}$:Eu or $L_XSi_YO_ZN_{(2/3X+4/3Y-2/3Z)}$:Eu (where L represents Sr, Ca, or Sr and Ca). It is preferable that X and Y in the general formulas are X=2, Y=5, or X=1, Y=7, however, arbitrary values can be used. As concrete basic component elements, it is preferable that fluorescent materials represented in Mn-added $(Sr_XCa_{1-X})_2Si_5N_8$:Eu; $Sr_2Si_5N_8$:Eu; $Ca_2Si_5N_8$:Eu; $Sr_XCa_{1-X}Si_7N_{10}$:Eu; $SrSi_7N_{10}$:Eu; and $CaSi_7N_{10}$:Eu are employed. Here, the fluorescent material may include at least one element selected from the group consisting of Mg, Sr, Ca, Ba, Zn, B, Al, Cu, Mn, Cr, and Ni.L is any element of Sr, Ca, Sr, and Ca. The composition ratio of Sr and Ca can be varied, if desired. Employing Si in composition of the fluorescent material can provide the low cost fluorescent material with preferable crystallinity.

[0086] In this phosphor, Eu^{2+} is used as an activation agent for an alkaline-earth-metal group silicon nitride as a base material. Added Mn accelerates diffusion of Eu^{2+}, and improves light-emitting efficiency such as light-emission luminance, energy efficiency, or quantum efficiency.Mn is included in the material, or is added in the process as Mn alone or Mn compounds, then is burned with the material.

[0087] The phosphor contains at least one element selected from the group consisting of Mg, Ga, In, Li, Na, K, Re, Mo, Fe, Sr, Ca, Ba, Zn, B, Al, Cu, Mn, Cr, O, and Ni in the basic component elements, or together with the basic component elements. These elements have the effect increasing the particle size, or improve light-emitting luminance. In addition, B, Al, Mg, Cr, and Ni have the effect reducing persistence.

[0088] This type pf nitride group phosphor absorbs a part of light emitted by the light emitting element, and emits luminescent radiation of a range between yellow and red. The nitride group phosphor is used together with the YAG group phosphor, thus, light emitted by the light emitting element is mixed with luminescent radiation of a range between yellow and red by the nitride group phosphor. Accordingly, a light emitting device that emits warm white range mixed light is provided. It is preferable that the aluminum garnet group phosphor is contained additionally to the nitride phosphor if other phosphor is added thereto. Including the aluminum garnet group phosphor can adjust desired chromaticity. For example, the yttrium aluminum oxide phosphor material activated with cerium can absorb a part of light from the light emitting element, and emit luminescent radiation of yellow range. In this case, white range light can be radiated by mixing light emitted by the light emitting element, and yellow light of the yttrium aluminum oxide phosphor material. Accordingly, in the case where the yttrium aluminum oxide phosphor material is mixed with a phosphor that emits red luminescent radiation in the transparent light conversion member, the mixed luminescent radiation and blue light emitted by the light emitting element or blue light converted by a phosphor are combined, thus, it is possible to a light emitting device that emit white range light. Particularly, it is preferable that a white range light emitting device that has the chromaticity is located on the blackbody line in the chromaticity diagram. In order to provide a light emitting device with a desired color temperature, the amounts of the yttrium aluminum oxide phosphor material and the phosphor that emits red luminescent radiation can be changed if necessary. Particularly, this light emitting device that white range mixed light is aimed at improving the special color rendering index R9. In a conventional white range light emitting device that is composed of the combination of a blue light emitting element and an yttrium aluminum oxide phosphor material activated by cerium, the special color rendering index R9 is nearly zero in the periphery of the color-temperature Tcp = 4600 K, and the reddish component is insufficient. Accordingly, there was a problem to be solved that the special color rendering index R9 was improved. On the other hand, in the present invention, the phosphor that emits red luminescent radiation is used together with the yttrium aluminum oxide phosphor material, thus, the special color rendering index R9 can be increased to about 40 in the periphery of the color-temperature Tcp = 4600 K.

[0089] A process for producing the phosphor ($(Sr_XCa_{1-X})_2Si_5N_8$:Eu) according to the present invention is now described as follows. However, the present invention is not limited to this process. The aforementioned phosphor contains Mn, and O.

[0090] Although it is preferable to use materials of Sr and Ca as a single material, compounds, such as an imido compound and an amide compound, can be used. The materials of Sr and Ca may contain B, Al, Cu, Mg, Mn, MnO, Mn_2O_3, Al_2O_3, and so on. The materials of Sr and Ca are pulverized in an argon atmosphere in a glove box. It is preferable that Sr and Ca obtained by pulverization have the average particle size of a range between 0.1 μm and 15 μm, but they are not limited to this range. In order to further improve a mixture state, at least one of metal Ca, metal Sr, and metal Eu may be alloyed. After nitiriding and pulverization, it can be used as a material.

[0091] Although it is preferable to use the material of Si as a single material, compounds, such as a nitride compound, an imido compound and an amide compound, can be used. Si_3N_4, $Si(NH_2)_2$, Mg_2Si, and so on, can be given as the examples. It is preferable that the purity of the material of Sr is 3N or more, but the martial may contain a compound such as Al_2O_3, Mg, metal boride (Co_3B, Ni_3B, and CrB), manganese oxide, H_3BO_3, B_2O_3, Cu_2O, and CuO. Si is pulverized in an argon atmosphere or nitrogen atmosphere, in a glove box, similarly to the materials of Sr and Ca. It is preferable that the average particle size of Si compound is about 0.1 μm to 15 μm.

[0092] Subsequently, Sr and Ca are nitrided in a nitrogen atmosphere. As for Sr and Ca, they may be mixed and nitrided, or they may be nitrided separately. Thus, nitrides of Sr and Ca can be obtained. In addition, the material Si is nitrided in a nitrogen atmosphere. Thus, silicon nitride can be obtained.

[0093] The nitride of Sr, Ca, or Sr-Ca is pulverized. The nitride of Sr and Ca, or Sr-Ca nitride is pulverized in an argon atmosphere or a nitrogen atmosphere, in a glove box. The nitride of Si is pulverized similarly. In addition, the compound of Eu, Eu_2O_3 is also pulverized similarly. The europium oxide is employed as the compound of Eu, however metal europium, an europium nitride, or the like, can be employed. Additionally, an imide compound, an amide compound, or the like, can be employed as the material of Z. It is preferable that the europium oxide has high purity. However, a europium oxide available on the market also can be employed. It is preferable the nitride of alkaline earth metal, the silicon nitride, and the europium oxide have the average article size about 0.1 μm to 15 μm, after pulverization.

[0094] The above materials may contain at least one element selected the group consisting of Mg, Sr, Ca, Ba, Zn, B, Al, Cu, Mn, Cr, O, and Ni. In addition, an adjusted content of the above element such as Mg, Zn, and B may be mixed in the following processes. These elements can be added as single materials to the material, but they are normally added in a compound form. H_3BO_3, Cu_2O_3, $MgCl_2$, MgO-CaO, Al_2O_3, metal boride (CrB, Mg_3B_2, AlB_2, and MnB), B_2O_3, Cu_2O, and CuO can be given as examples of the this type of compound.

[0095] After the above pulverization, the nitride of Sr, Ca, and Sr-Cr, the nitride of Si, and the compound of Eu, Eu_2O_3 are mixed, and then Mn is added thereto. Since the mixture of them tends to be oxidized, they are mixed in an Ar atmosphere or a nitrogen atmosphere in a glove box.

[0096] Finally, the mixture of the nitride of Sr, Ca, and Sr-Cr, the nitride of Si, and the compound of Eu, Eu_2O_3 is burned in an ammonia atmosphere. Burning them can provide the phosphor represented by the formula $(Sr_XCa_{1-X})_2Si_5N_8$:Eu with Mn added thereto. In addition, the composition ratio of materials can be changed so as to obtain composition of a target phosphor.

[0097] A tubular furnace, a small furnace, a high-frequency furnace, a metal furnace, and so on, can be used for burning. The burning is performed at burning temperature in the range 1200 to 1700°C, however it is preferable that the burning temperature is 1400 to 1700°C. It is preferable to use single-stage burning where burning is performed while gradually increasing the temperature from 1200 to 1500°C for several hours. However, two-stage burning (multi-stage burning) may be used. In the two-stage burning, burning in a first stage is performed from 800 to 1000°C, and burning in a second stage is performed while gradually increasing the temperature from 1200 to 1500°C. It is preferable that the materials of the phosphor are burned in a crucible or a boat of boron nitride (BN) material. Instead of the crucible of a boron nitride material, a crucible of alumina (Al_2O_3) also can be used.

[0098] The target phosphor can be obtained by the aforementioned producing method. In the embodiment of the present invention, the nitride group phosphor is particularly used as the phosphor that emits reddish luminescent radiation. However, in this embodiment of the present invention, the light-emittin apparatus can have the above YAG group phosphor and the phosphor capable emitting red range luminescent radiation. This type of phosphor capable of emitting red group luminescent radiation is a phosphor that is excited by the light with a wavelength 400 to 600 nm and emits luminescent radiation. For example, Y_2O_2S:Eu, La_2O_2S:Eu, CaS:Eu, SrS:Eu, ZnS:Mn, ZnCdS:Ag, Al, ZnCdS:Cu, Al, and so on, can be given as examples of the phosphor. Using the phosphor capable of emitting red range luminescent radiation together with the YAG group phosphor can improve the color rendering of light emitting device.

[0099] As for the aluminum garnet group phosphor, and the phosphor capable of emitting luminescent radiation of red group light, typically such as a nitride group phosphor, that are formed as mentioned above, a light conversion member consisting of one layer in the periphery of the light emitting element may includes two or more kinds of the phosphors, or a light conversion member consisting of two layers may include one or two kind(s) in each layer. In this construction, mixed light can be obtained by color mixture of light from different kinds of phosphors. In this case, in order to provide more preferable color mixture of light emitted from each phosphor material, and to reduce color unevenness, it is preferable that the respective average particle sizes and shapes of phosphors are similar. In consideration that the nitride group phosphor absorbs a part of light with a wavelength converted by the YAG phosphor, the light conversion member is preferably formed such that the nitride group phosphor is located in a position closer to the light emitting element relative to the YAG phosphor. In this construction, the nitride group phosphor does not absorb a part of light with a wavelength converted by the YAG phosphor. Accordingly, it is possible to improve the color rendering of mixed light as compared with the case where the YAG group phosphor and the nitride group phosphor are mixed and contained.

[0100] <Oxynitride Group Phosphor>

An oxynitride phosphor represented by the following general formula can be contained additionally to the aforementioned phosphor materials if other phosphor is added to the phosphor material according to the present invention. $L_xM_y-O_zN_{((2/3x+(4/3)y-(2/3)z)}:R$

where L represents at least one element selected from the group consisting of Be, Mg, Ca, Sr, Ba and Zn, and M represents at least one element selected from the group consisting of C, Si, Ge, Sn, Ti, Zr and Hf. In addition, N is nitrogen, O is oxygen, and R is a rare earth element. x, y and z satisfy the following values.

$x = 2$, $4.5 \le y \le 6$ and $0.01 \le z \le 1.5$,

or $x = 1$, $6.5 \le y \le 7.5$ and $0.01 \le z \le 1.5$,

or $x = 1$, $1.5 \le y \le 2.5$ and $1.5 \le z \le 2.5$

A producing method of the oxynitride phosphor is now described. However, needless to say, the present invention is not limited to this producing method. First, nitride of L, nitride and oxide of M, and oxide of rare earth element are mixed as a material so as to achieve a prescribed composition ratio. The composition ratio of materials can be changed so as to obtain composition of a target phosphor.

[0101] Subsequently, the aforementioned material of mixture is placed in a crucible, and is burned. A tubular furnace, a small furnace, a high-frequency furnace, a metal furnace, and so on, can be used for burning. The burning is performed at burning temperature in the range 1200 to 1700°C, however it is preferable that the burning temperature is 1400 to 1700°C. However, the burning temperature is not limited to these ranges. It is preferable that the materials of the phosphor are burned in a crucible or a boat of boron nitride (BN) material. Instead of the crucible of a boron nitride material, a crucible of alumina (Al_2O_3) also can be used. In addition, the burning is performed preferably in a reducing atmosphere. A nitrogen atmosphere, a nitrogen-hydrogen atmosphere, an ammonia atmosphere, and an inert gas atmosphere such as argon can be given as examples of the reducing atmosphere. The target oxynitride phosphor can be obtained by the aforementioned producing method.

[0102] <Alkaline-Earth Metal Silicate Phosphor>
The light emitting device according to this embodiment can include an alkaline-earth metal silicate phosphor activated by europium as a phosphor that absorbs a part of light emitted by the light emitting element and emits luminescent radiation of wavelength different from the absorbed light. In the case where the light emitting device includes the alkaline-earth metal silicate phosphor, the light emitting device can emit warm mixed light by using light of the blue range as excitation light. It is preferable that the alkaline-earth metal silicate phosphor is an alkaline-earth metal orthosilicate phosphor represented by the following general formula.

$(2\text{-}x\text{-}y)SrO \cdot x(Ba, Ca)O \cdot (1\text{-}a\text{-}b\text{-}c\text{-}d)SiO_2 \cdot$
$aP_2O_5bAl_2O_3cB_2O_3dGeO_2{:}yEu^{2+}$ (where $0 < x < 1.6$, $0.005 < y < 0.5$, and $0 < a, b, c$ and $d < 0.5$)
$(2 - x - y)BaO \cdot x(Sr, Ca)O \cdot (1 - a - b - c - d)SiO_2 \cdot$
$aP_2O_5bAl_2O_3cB_2O_3dGeO_2{:}yEu^{2+}$ (where $0.01 < x < 1.6$, $0.005 < y < 0.5$, and $0 < a, b, c$ and $d < 0.5$)

In this case, it is preferable that at least one of the values a, b, c and d is more than 0.01.

[0103] The light emitting device according to the present invention can include an alkaline-earth metal aluminate phosphor activated by europium and/or manganese, $Y(V, P, Si)O_4{:}Eu$, and an alkaline-earth metal-magnesium-disilicate phosphor represented by the following formula as a phosphor of alkali-earth metal salt phosphor in addition to the aforementioned alkaline-earth metal silicate phosphor.

$Me(3 - x - y)MgSi_2O_3{:}xEu, yMn$ (where $0.005 < x < 0.5$, $0.005 < y < 0.5$, and Me represents Ba and/or Sr and/or Ca).

[0104] A producing method of the phosphor of alkaline-earth metal silicate phosphor according to this embodiment is now described.

[0105] In production of the alkaline-earth metal silicate phosphor, depending on a selected composition, stoichiometric amounts of alkaline-earth metal carbonate, silicon dioxide and europium oxide are tightly mixed, and they are converted into a desired phosphor at temperatures of 1100°C and 1400°C in a reducing atmosphere by solid reaction typically used in production of a phosphor. In this case, less than 0.2 mol of ammonium chloride or other chloride is preferably added. In addition, germanium, boron, aluminum, and phosphorus can be substituted for a part of silicon, or manganese can be substituted for a part of europium, if necessary.

[0106] The aforementioned phosphors, that is, one or combination of an alkaline-earth metal aluminate phosphor activated by europium and/or manganese, $Y(V, P, Si)O_4{:}Eu$, and $Y_2O_2S{:}Eu^{3+}$ can achieve light-emission color of a desired color temperature and high color reproduction characteristics.

[0107] <Other Phosphor>
In this embodiment, a phosphor that is excite by light from ultraviolet to visible range and emits luminescent radiation can be used. Specifically, the following phosphors can be given as examples of the phosphor.

(1) an alkaline-earth halogen apatite phosphor activated by Eu, Mn, or Eu and Mn, for example, $M_5(PO_4)_3(Cl, Br){:}Eu$ (where M represents at least one element selected from the group consisting of Sr, Ca, Ba, and Mg), and $Ca_{10}(PO_4)_6ClBr{:}Mn, Eu$, and so on
(2) an alkaline-earth metal aluminate phosphor activated by Eu, Mn, or Eu and Mn, for example, $BaMg_2Al_{16}O_{27}{:}Eu$; $BaMg_2Al_{16}O_{27}{:}Eu, Mn$; $Sr_4Al_{14}O_{25}{:}Eu$; $SrAl_2O_4{:}Eu$; $CaAl_2O_4{:}Eu$; $BaMgAl_{10}O_{17}{:}Eu$; $BaMgAl_{10}O_{17}{:}Eu, Mn$; and so on
(3) an rare-earth oxide sulfide activated by Eu, for example, $La_2O_2S{:}Eu$, $Y_2O_2S{:}Eu$, $Gd_2O_2S{:}Eu$, and so on
(4) $(Zn, Cd)S{:}Cu$; $Zn_2GeO_4{:}Mn$; $3.5MgO \cdot 0.5MgF_2 \cdot GeO_2{:}Mn$; $Mg_6As_2O_{11}{:}Mn$; $(Mg, Ca, Sr, Ba)Ga_2S_4{:}Eu$; $Ca_{10}(PO_4)_6FCl{:}Sb, Mn$

[0108] (Diffusion Agent)
The light conversion member according to this embodiment may contain a diffusion agent in addition to the aforementioned phosphor material. Furthermore, a transparent dissipation member or a later-described transparent member 303 may contain a diffusion agent. Specifically, barium titanate, titanium oxide, aluminum oxide, silicon oxide, and mixture of them can be preferably used as the diffusion agents. In this case, it is possible to provide a light emitting device with excellent characteristics of directivity.

[0109] In this specification, the diffusion agent refers to a material that has a center particle size not less than 1 nm to less than 5 μm. The diffusion agent of not less than 1 nm to less than 5 μm scatters light from the phosphor material, and thus suppresses color unevenness that tends to appear in the case where a phosphor material with a large particle size. For this reason, this type of diffusion agent is preferably used. A diffusion agent of not less than 1 nm to less than 1 μm has a small interference effect on the wavelength of light from the light emitting element, but hand can increase viscosity of resin without reduction of luminous intensity. Accordingly, in the case where resin containing the phosphor material and so on is dropped on a target location to form the light conversion member, the phosphor material can be uniformly dispersed in the resin within a syringe, and kept in this state. Therefore, even in the case where a phosphor material with a large particle size that is relatively difficult for handling, it is possible to produce the light conversion member at high yield. As mentioned above, diffusion agents has different effects depending on their particle size range, thus, diffusion agents are used by selecting or combining them depending on the purpose of use.

[0110] (Filler)
The light conversion member according to this embodiment may contain filler in addition to the phosphor material. Furthermore, the transparent dissipation member or the transparent member 303 may contain filler. In this case, it is possible to improve thermal shock resistance and heat dissipation characteristics of the members.
[0111] In this specification, specifically, the filler is formed of a material similar to the diffusion agent, but has a center particle size dissimilar to the diffusion agent. The filler refers to a material that has a center particle size not less than 5 μm to not more than 100 μm. In the case where a transparent resin that is a material of the light conversion member contains the filler with a particle size of this range, not only chromaticity unevenness of the light emitting device is improved by light dispersion, but also heat conductivity characteristics and thermal shock resistance of the transparent resin are improved. Accordingly, in the case where the light conversion member contains the filler in addition to the phosphor material, it is possible to improve heat dissipation characteristics of the light conversion member. Additionally, the transparent resin can be adjusted so as to have constant flowability for a long time, and the light conversion member can be formed in a desired location. Accordingly, it is possible to mass-produce the light emitting device at high yield. It is preferable that mixture ratio of the phosphor material, the filler, and resin as the binding agent is suitably adjusted to improve thermal shock resistance and heat dissipation characteristics of the light conversion member.
[0112] The filler preferably has a particle size and/or a shape similar to the phosphor material. In this specification, the similar particle size refers to a center particle with difference of less than 20% between particles. The similar shape refers a shape having a degree of circularity ((a degree of circularity) = (the perimeter of a perfect circle that has an area equal to a projected area of a particle) divided by (the perimeter of a projected shape of the particle)) representing a degree of similarity to a perfect circle with difference of less than 20% between particles. In the case where the filler is used, the filler interacts with the phosphor material, thus, it is possible to disperse the phosphor material well in resin and to suppress color unevenness.
For example, the phosphor material and the filler can have a center particle of 15 μm to 50 μm, preferably 20 μm to 50 μm. This adjustment of particle size can space particles at preferable interval between them. Accordingly, light-outgoing paths can be adequately provided. Therefore, it is possible to suppress reduction of luminous intensity due to mixture of filler, and to improve directivity characteristics.
[0113] SECOND EMBODIMENT
A light emitting device according to a second embodiment has a heat dissipation member having a flow path of a refrigerant includes a first heat dissipation member that has a first flow path in a side where the light emitting element is mounted, and a second heat dissipation member that has a second flow path in a side where light from the light emitting element is incident. The second heat dissipation member includes the light conversion member, in the construction of the light emitting device according to the first embodiment. That is, the light emitting device according to the present invention comprises a water-cooling heat dissipation member that suppress heat conducted from the light emitting device, and the light conversion member containing the phosphor that is provided thereon. Accordingly, since self-heat generation of the phosphor can be suppressed, and deterioration of the phosphor can be prevented, the output of light emitting device does not deteriorate. Therefore, high power light, for example white group light, can be emitted. The other construction is similar to the first embodiment.
[0114] Specifically, the light emitting device according to this embodiment has the first heat dissipation member that aids heat dissipation from the light emitting element, and the second heat dissipation member that aids heat dissipation from the light conversion member. The light conversion member is provided in a region where light from the light emitting element is incident in the second heat dissipation member. The second heat dissipation member has the second flow path in a side where the light conversion member that is provided. The second flow path includes the refrigerant that aids heat dissipation from the light conversion member. Accordingly, self-heat generation of the phosphor that is exposed to high power and high energy excitation light can be suppressed. The first heat dissipation member has a flow path of the refrigerant similarly to the second heat dissipation member whereby aiding heat dissipation from the light emitting element that emits high power light. Accordingly, heat dissipation characteristics are improved in terms of the whole light emitting device. Therefore it is possible to provide a light emitting device that radiates high power light.
[0115] In addition, the flow path in the heat dissipation member according to this embodiment preferably includes a third flow path that connects the first flow path to the second flow path. The light emitting device has a pair of inlet and outlet commonly for first and second flow paths, thus, the light emitting element and the light conversion member can be cooled by a single system. Accordingly, the light emitting device can be small as compared with the case where a light emitting element and a light conversion member are cooled by separated systems. In addition, it is possible to simplify a cooling mechanism of the light emitting device.
[0116] The light emitting device according to this embodiment has the first heat dissipation member that has the first flow path of the refrigerant in a side where the light emitting element is mounted, an electrically insulating member, a supporting substrate, and the second heat dissipation member that has the second flow path of the refrigerant in a side where the light conversion member is provided, which are at least laminated. In this construction, it is possible to easily provide the light emitting device according to the present invention.

[0117] The inlet or the outlet is formed in the heat dissipation member. The insulating member and the supporting substrate have a through hole that partially forms the third flow path. Accordingly, the refrigerant liquid can be admitted to and ejected from a side where the light emitting device is mounted. Therefore, a device for supplying the refrigerant to the light emitting device, or the like, does not affect optical characteristics of the light emitting device.

[0118] A conductive member that contains at least one element selected the group consisting of Au, Ag, and Al is coated on at least one of main surfaces of the insulating member. In addition, one electrode of the light emitting element is electrically connected to the conductive member that is coated on the at least one of main surfaces of the insulating member via a conductive wire and the conductive member, another electrode is electrically connected to the first heat dissipation member. That is, the supporting substrate and the first heat dissipation member have polarities different from each other. A pair of positive and negative electrodes of the light emitting element are electrically connected to the supporting substrate and the first heat dissipation member. In this construction, it is possible to easily supply electric power to the light emitting element. The components according to this embodiment will be described.

[0119] The components of the light emitting device according to the second embodiment are now described. (Heat Dissipation Member)

The heat dissipation member in the light emitting device according to this embodiment has at least the first heat dissipation member that has the first flow path in a side where the light emitting element is mounted, and the second heat dissipation member that has the second flow path in a side where light from the light emitting element is incident. The light emitting element according to this embodiment is mounted on the first heat dissipation portion. However, needless to say, the present invention is not limited to this arrangement. For example, other member with high heat conductivity, specifically a submount where the light emitting element is mounted in a flip chip mounting manner may be provided between the light emitting element and the first heat dissipation member as an auxiliary element. Hereinafter, the first heat dissipation member and the second heat dissipation member are described in more detail.

[0120] The first heat dissipation member according to this embodiment refers to a member that has the flow path for cooling the light emitting element, is provided with the light emitting element directly or through a conductive adhesive agent thereon, and conducts heat generated from the light emitting element externally of the light emitting device. In addition, the second heat dissipation member according to this embodiment refers to a member that has the flow path for cooling the phosphor, is provided with the light conversion member containing the phosphor thereon, and conducts heat generated from the phosphor externally of the light conversion member. In this case, the second heat dissipation member is formed of a material that can pass at least light from the light emitting element, or a material that can pass light from both the light emitting element and the light conversion member. Thus, the light conversion member is provided on at least one of a main surface in a side where light is observed on the second heat dissipation member, and a main surface in a side where light from the light emitting element is incident. Although the light conversion member is connected directly to the second heat dissipation member, the light conversion member is not limited to this form. Needless to say, the light conversion member may be mounted to the second heat dissipation member so as to sandwich a transparent member other than them between them. In addition, the shape of the light conversion member in a side where light is observed can have a lens shape in consideration of the optical characteristics of light from the light emitting device. The heat dissipation member may have a transparent part that contains the phosphor to serve as the light conversion member. Moreover, the flow path of the refrigerant for cooling the phosphor may be formed inside the light conversion member.

[0121] In this embodiment, the flow path of the refrigerant is applicable to a path closed or opened externally of the light emitting device. As one example of the heat dissipation member having an opened flow path, the heat dissipation member can have a flat plate that is made of a metal, such as copper and aluminum, and is provided with a flow path for passing the refrigerant therethrough. In the case where the heat dissipation member has a transparent part as the second heat dissipation member, a transparent resin, a quartz material, or the like, is selected as a material of the transparent part. In addition, in order to circulate the refrigerant through the heat dissipation, the heat dissipation member has at least one pair of an inlet and an outlet on its outer wall surface. As shown in Fig. 7, each of heat dissipation members 115 and 109 can have a plurality of plate-shaped members at least one of which has a groove or asperities, and through holes as the inlet and outlet.

For example, the heat dissipation members have second plate-shaped members 115b and 109b that have grooves or recessed shapes and through holes as the inlets and outlets, and first plate-shaped members 115a and 109a. Surfaces of the first plate-shaped members 115a and 109a and second plate-shaped members 115b and 109b that are opposed to each other are bonded, thus, the flow path of the heat dissipation member can be formed. Needless to say, in this embodiment, the shape of the heat dissipation is not limited to the illustrated shape in Fig. 7. In the first plate-shaped members 115b and 109b as portions of the heat dissipation member, for example, a recessed portion is formed so as to be gradually wider and then narrower from the location where one of openings (inlet or outlet) is formed to other opening as shown in Fig. 10. This allows the refrigerant to smoothly circulate through the flow path. Additionally, it is preferable that small grooves or asperities are formed on an inner wall surface of the recessed portion. This increases the contact area between the refrigerant and the heat dissipation member, and thus can improve a heat dissipation effect for the light emitting device.

[0122] As one example of the heat dissipation member having a closed flow path, the heat dissipation member can have a heat pipe that is made of a metal, such as copper and aluminum, and is provided with the refrigerant sealed therein. Particularly, in another embodiment, a heat pipe is a metal tube that is made of a metal, such as copper and aluminum, in which a hydraulic fluid for conveying heat, such as water, CFCs, alternative CFCs and Fluorinert, is sealed, for example. In this case, the hydraulic fluid is heated and evaporated in a heat input part (high temperature part), and the evaporated liquid moves and then liquefied in a heat dissipation part (lower temperature side). The liquefied hydraulic fluid is moved back to the heat input portion by capillary phenomenon, thus this cycle is repeated. Accordingly, a heat conveying member with high heat conductivity can be provided.

[0123] The heat dissipation member can have various types of shapes and sizes in consideration of a heat dissipation direction and a heat dissipation effect. For example, asperities are formed on the inner wall surface of the first flow path that is opposed to a backside surface of the light emitting element as shown in Fig. 9. This increases the contact area between the aforementioned inner wall surface and the refrigerant as compared with the case where asperities are not formed, and thus can improve the heat dissipation characteristics from the light emitting element. In addition, asperities are formed on the inner wall surface of the second flow path that is opposed to the light conversion member. This increases the contact area between the aforementioned inner wall surface and the refrigerant as compared with the case where asperities are not formed, and thus can improve the heat dissipation characteristics from the light conversion material. In the light emitting device has the third flow path connecting the first flow path to the second flow path such that the first and second flow paths extending in parallel, the inner wall surfaces of the first and second flow paths preferably have the same shape. In this case, the pressure of the refrigerant can be uniform inside the light emitting device. Therefore, it is possible to provide a high reliable light emitting device.

[0124] In the first heat dissipation member formed in a plate shape, it is preferable that the minimum distance d (mm) between its surface on which the light emitting element is mounted and the inner wall surface of the first flow path satisfies the following Equation.

$$0.05 < d < (C/800) \qquad \text{(Equation 1)}$$

where C is the thermal conductivity in W/mK of a plate-shaped member that composes the heat dissipation member. For example, in the case where the first heat dissipation member is formed of oxygen-free copper, it is preferable that d (mm) is set within the following range.

$$0.05 < d < 0.5 \qquad \text{(Equation 2)}$$

Additionally, in the case where the first heat dissipation member is formed of ceramics, such as alumina and aluminum nitride, it is preferable that d (mm) is set within the following range.

$$0.05 < d < 0.25 \qquad \text{(Equation 3)}$$

If the value of d is lager than the upper limit, the thermal resistance of the heat dissipation member becomes too large. In this case, thermal interference between the light emitting elements adjacent to each other becomes remarkable. Accordingly, the light emitting elements cannot be mounted at high density. If the value of d is smaller than the lower limit, the plate-shaped member cannot be easily processed.

[0125] (Supporting Substrate)

The supporting substrate refers to a member that supplies electric power to the light emitting element, and serves as a support member for supporting other components to achieve sufficient mechanical strength of the light emitting device. The supporting substrate can have various sizes in consideration of heat dissipation characteristics, the output of light emitting device and so on, and have various shapes in consideration of the shape of light emitting device. In addition, in order to control distribution of light, a reflector may be provided on a part of the supporting substrate.

[0126] The supporting substrate can have an extended portion that extends externally of the light emitting device as shown in Fig. 6. The extended portion can be provided with a through hole for securing the light emitting device 100 to an external mount substrate, or a refrigerant supply device such as a water stream pump, for example. In addition, as shown in Fig. 7, the supporting substrate may have a tapered through hole with inclined walls that reflect light from the light emitting element in the direction where the light is observed. The inner walls of the through hole are opposed to the light emitting element mounted in the first heat dissipation member. In addition, a reflector layer may be formed on the inclined walls for excellent reflection of the light from the light emitting element. In order to efficiently dissipate heat conducted from the light emitting element toward the heat dissipation member side, the supporting substrate preferably has high heat conductivity. Ceramics, copper, aluminum, and a phosphor bronze plate can be given to employ each of them alone as examples of materials with high heat conductivity. In addition, it is preferably used with silver or palladium that is coated on its surface, or with metal plating such as silver and gold, solder plating or the like that is performed on its surface.

[0127] (Insulating Member)

The insulating member according to this embodiment refers to a member that is provided between the first heat dissipation member and the supporting substrate so as to insulate them from each other. The insulating member is provided with metal, such as Au, Ag and Al, coated on its surface(s) that is/are opposed to the conductive supporting substrate and/or the first heat dissipation member. Wiring for supplying electric power to the light emitting element is configured of the metal coated on the surface that is opposed to the supporting substrate. The metal coated on the surface that is opposed to the first heat dissipation member becomes a layer that bonds the first heat dissipation member and the insulating member together.

[0128] The insulating member has a shape corresponding to the first heat dissipation member and the supporting substrate, for example, a plate shape as shown in Figs. 6 and 7. The insulating member is made of an electrically insulating material, such as resin, alumina, and aluminum nitride. It is preferable that metal containing at least one element selected from the group consisting of Au, Ag and Al is formed on at least one of surfaces of the insulating member that are opposed to the first heat dissipation member and the supporting substrate. Accordingly, it is possible to easily provide electrical connection to the light emitting element. Alternatively, wiring can be performed to bond a wire for supplying electric power to the light emitting element.

In addition, as shown in Fig. 7, the supporting substrate may have a tapered through hole. Inner walls of the through hole are opposed to the light emitting element mounted in the first heat dissipation member. In addition, a reflector layer may be formed on the inclined walls for excellent reflection of the light from the light emitting element.

A pair of through holes corresponding to the openings that communicate with the flow path of the heat dissipation portion can be formed on the aforementioned supporting substrate and insulating member so as to form the third flow path. In addition, O-rings are preferably provided in respective parts of the through holes where the first, second and third flow paths are connected to each other in order to prevent leakage of the refrigerant. The O-rings are preferably made of a material such as silicone resin.

[0129] THIRD EMBODIMENT

A light emitting device of a third embodiment of the present invention comprises a heat dissipation member that is formed of two plate-shaped members that form a flow path for flowing cooling fluid between them, and a plurality of light emitting elements that are mounted to be two-dimensionally arranged on a main surface of the heat dissipation member, wherein a plurality of protruding portions are formed in the surface of the plate-shaped member inside the flow path, and at least some of the plurality of protruding portions are formed such that their centers are located between the light emitting elements and a substantially central part of the light emitting element. The other construction is similar to the first embodiment unless otherwise noted.

[0130] A heat dissipation member according to the third embodiment is now described.

(Heat Dissipation Member)

The heat dissipation member (hereinafter, occasionally referred to as a "heat sink") according to the present invention is a heat sink comprising a laminated-plate-shaped member that has a first plate-shaped member with a first surface thermally connected to a heat generating element and a second plate-shaped member connected to a second surface of the first plate-shaped member, and is provided with an inlet for admission of a fluid and an outlet communicating with the inlet for ejection of the fluid, wherein asperities are formed on the second surface of the first plate-shaped member.

[0131] Since the asperities are formed on the second surface of the first plate-shaped member, it is possible to increase the surface area where the fluid flows in the same region. That is, protruding parts of the asperities that are formed on the second surface of the first plate-shaped member play a role like a heat dissipation fin. Since the fluid flows in a surface with stepped parts, it flows not only straightly but variably in its flowing direction and flowing velocity. Accordingly, it is possible to efficiently cool heat from the heat generating element. In addition, even in the case where the diameter of the inlet is small in order to make the heat sink thin or small, the light emitting device has a sufficient cooling effect.

[0132] In this case, the connection between the first plate-shaped member and the heat generating element is not limited to direct contact between them, but includes thermal connection between them. In other words, the construction is not limited as long as a thermal conductive path is formed between the first plate-shaped member and the heat generating element. For example, one layer of or a plurality of layers of a eutectic material may be interposed between them. The fluid refers to a cooling medium such as pure water and low melting-point liquid.

[0133] In the heat sink according to the present invention, the asperities are preferably formed in a region that is opposed to a connection region of the heat generating element. In this case, it is possible to increase a heat dissipation area in contact with the fluid to twice or more, and to reduce heat density (density of heat flow) in the second surface.

Accordingly, efficient cooling can be achieved.

[0134] In the heat sink according to the present invention, the asperities that are formed on the second surface of the first plate-shaped member preferably have the height of the stepped part of not less than 10 μm to not more than 500 μm. The asperity arrangement is formed together with formation of water path on the plate-shaped member by chemical etching, and so on. Its height is preferably set to not less than 10 μm in terms of precision of processing. In addition, since the flow amount depends on the amount of cut-away part by etching, if the above range exceeds 500 μm, a fluid that does not serve for cooling exists. Additionally, in this case, since an excess fluid is circulated, this causes over pressure, and less efficiency. For this reason, the height is preferably set to not more than 500 μm.

[0135] The asperities more preferably have the height of the stepped part of not less than 100 μm to not more than 300 μm. In the case where the height of the stepped part is set to the above range, it is possible to more efficiently cool the heat sink.

[0136] Furthermore, the heat sink according to the present invention is a heat sink comprising a laminated-plate-shaped member that has the first plate-shaped member with the first surface thermally connected to the heat generating element and the second plate-shaped member connected to the second surface of the first plate-shaped member, and is provided with the inlet for admission of the fluid and the outlet communicating with the inlet for ejection of the fluid, wherein the first plate-shaped member has a surface area (b) of the second surface that is opposed to a contact region of the heat generating element is larger than a contact area (a) of the heat generating element in the first surface. The inventors observed, in thermal conduction where heat is dissipated from the heat surface, the temperature distribution of thermal conduction of heat that is dissipated from the heat generating element was conveyed in the heat sink toward the second surface of the first plate-shaped member while spreading at 45° relative to the thickness direction. For this reason, in the case where surface emission type light emitting devices, and so on, as the heat generating elements are mounted at high density, heat generated by the heat generating elements adjacent to each other is overlapped during conveyed in the thickness direction. This causes thermal interference and a large amount of heat is locally produced. As a result, in the case where surface emission type light emitting devices, and so on, as the heat generating elements are mounted at high density, available electric power applied to each of the surface emission type light emitting devices is limited to low power. However, according to the present invention, in the case where semiconductor devices are mounted at high density as mentioned above, the heat dissipation surface of the aforementioned construction is provided, it is possible to remarkably increase available electric power applied thereto. The applied electric power refers to the product of a current and a voltage that are applied the semiconductor devices such as surface emission type light emitting devices. The heat density refers to a value obtained by dividing the applied electric power by a projected area of the device. According to the present invention, for example, 2 W/mm or more of applied electric power is available. In addition, high-density mount refers to a mount form where three or more of heat generating elements are mounted such that the heat generating elements are spaced from each other at an interval smaller than the width of the heat generating element.

[0137] In the heat sink according to the present invention, it is preferable that the ratio between the contact area (a) of the heat generating element in the first surface and the surface area (b) of the second surface that is oppose to the contact region of the heat generating element is $0.2 \leq (a/b) < 1$. It is more preferable that the above range is $0.2 \leq (a/b) < 0.5$. If the surface area (b) of the second surface is five times or more the contact area (a) of the heat generating element in the first surface, considerable precision of processing is required. In the case of the above range, it is possible to further improve cooling efficiency.

[0138] It is preferable that the first surface of the first plate-shaped member is connected to the heat generating element so as to sandwich a eutectic material between them. In this case, it is possible to attach the heat generating element to the plate-shaped member at a low temperature without thermal damage to the heat generating element. In addition, it is possible to remain micromachining on the plate-shaped member, to make the light emitting device thin additionally to suppress thermal deformation, and to reduce thermal resistance.

[0139] It is preferable that the second surface of the first plate-shaped member is connected to the second plate-shaped member so as to also sandwich a eutectic material between them. A eutectic material is employed as an adhesive agent that attaches the plate-shaped members, thus, it is possible to the plate-shaped members at a relatively low temperature. It is possible to remain micromachining on the plate-shaped member, to make the light emitting device thin, and to reduce thermal resistance.

[0140] In addition, the semiconductor apparatus according to the present invention is a semiconductor apparatus comprising the aforementioned heat sink and the heat generating element formed of a semiconductor. The heat sink is employed, thus, it is possible to prevent thermal deterioration of device characteristics of the heat generating element. Therefore, it is possible to provide a semiconductor apparatus with excellent reliability.

[0141] It is preferable that the first surface of the first plate-shaped member is provided with one or more of the semiconductor device according to the present invention mounted thereon. The asperities that are formed on the second surface of the first plate-shaped member reduce heat density in the second surface. Accordingly, deterioration of light output due to self-heat generation of the heat generating element, thus, it is possible to mount a plurality of heat generating elements at high density.

[0142] In addition, in the light emitting device according to the present invention, it is preferable that the heat generating element is a semiconductor light emitting element. Since heat characteristics of a semiconductor light emitting element is sensitive to heat, it remarkably deteriorates due to heat. Particularly, a semiconductor laser (LD) and an LED generate a large amount of heat. In the present invention, the heat sink is provided, it is possible to mount the heat generating elements at high density, and to achieve high output. Additionally, since a nitride semiconductor light emitting element generates a large amount of heat among semiconductor light emitting elements, it is effective to provide the heat sink according to the present invention for such a nitride semiconductor light emitting element.

[0143] In the heat sink according to the present invention, in a process of attaching the plate-shaped members to each other, an adhesive member is formed on a surface of one of the plate-shaped members, and a metal layer is formed on an attachment surface of the other plate-shaped member, thus, they can be attached to each other. Not only the adhesive member but also the metal layer is formed, thus, wettability of the adhesive member is improved. Accordingly, it is possible improve bonding characteristics of the plate-shaped members that are bonded with each other. Therefore, it is possible further improve reliability of leakage of a cooling agent, and so on.

[0144] In the heat sink according to the present invention, the eutectic material is an adhesive material that contains at least one material selected from the group consisting of AuSn, AuSi, SnAgBi, SnAgCu, SnAgBiCu, SnCu, SnBi, PbSn, and In. In terms of wettability and bonding characteristics, the above adhesive material are preferable. As for a method for producing a heat sink according to the present invention, it is preferable that an attachment temperature of the eutectic material is not more than 500°C. The heat sink is produced at the above temperature range, thus, thermal deformation is remarkably improved.

[0145] In this construction of the present invention, for example, 10 or more of LEDs of a nitride semiconductor can be mounted on the heat sink at high density. In addition, it is possible provide a watt-class light source that continuously emits in the CW driving condition. Further, the heat sink according to the present invention is provided with one or more of high-power surface emission type semiconductor lasers mounted thereon, thus, even in the case of nitride semiconductor lasers that generate a large amount of heat, it is possible to provide a small size watt-class light source that continuously emits in the CW driving condition. Additionally, the heat sink according to the present invention can be provided with a plurality of watt-class light sources with one or more of semiconductor light emitting elements. Therefore, it is possible to provide a higher-power light source.

[0146] Particularly, the heat dissipation member according to the present invention is effective for a surface emission type semiconductor laser and a high brightness LED. However, it can be used as a heat dissipation member applicable to any semiconductor devices that generate heat.

[0147] In addition, it is preferable that the heat generating element is a semiconductor element that has a first conductivity type layer and a second conductivity type layer. In the case where a first conductivity type is an n type, a second conductivity type is a p type, and vice versa. In this embodiment, the first conductivity type layer is electrically connected to the heat sink, and the second conductivity type layer is electrically connected to a metal member that is formed above the heat sink so as sandwich an insulating layer between them.

[0148] The following describes an embodiment of the present invention with reference to the drawings.

Fig. 11 is a cross-sectional view schematically showing the structure of a semiconductor apparatus that has the heat sink according to the present invention. The semiconductor apparatus of Fig. 11 has the heat sink composed of a first plate-shaped member 2 and a second plate-shaped member 3. LED chips 1 as heat generating elements are mounted on the first plate-shaped member 2. The flow path 12 where a cooling fluid flows is formed between the first plate-shaped member 2 and the second plate-shaped member 3. The second plate-shaped member 3 has an inlet 36a and an outlet 36b of the fluid. The insulating member 4 is formed on the upper surface of the first plate-shaped member 2 except for a region for mounting the LED chips 1. A metal member 5 is formed on the insulating member 4. The first plate-shaped member 2 is electrically insulated from the metal member 5 by the insulating member 4. As for the LED chips 1 as the heat generating elements, their n-side electrodes forms on their upper surfaces are connected to the metal member 5 through wires. P-side electrodes of the LED chips 1 are formed on the bottom surfaces, and are connected to the first plate-shaped member 2. A metal cap weld member 6 is additionally formed on and is electrically connect to the metal member 5. The first plate-shaped member 2 and the second plate-shaped member 3 are also electrically connected to each other. A power supply 8 is connected to the cap weld member 6 and the second plate-shaped member 3. As for an electric connection path, the first plate-shaped member 2 and the metal member 5 are connected to each other via the heat generating elements 1. That is, the second plate-shaped member 3 and the first plate-shaped member 2 serve as leads that apply an electric current to the p-side electrodes of the LED chips 1, while the metal cap weld member 6 and the metal member 5 serve as leads that apply an electric current to the n-side electrodes of the LED chips 1. A cap 7 as a cover for protection of the LED chips 1 is formed on the cap weld member 6 located on the metal member 5. A window portion is formed in the cap 7 such that light emitted by the LED chips 1 can be observed, and is provided with a transparent window member 9 inserted therein.

[0149] Fig. 12 is a perspective view schematically showing the structure of the semiconductor apparatus shown in

Fig. 11. The metal member 5, the cap weld member 6 and the cap 7 are omitted for the sake of brevity. As shown in Fig. 12, the insulating member 4 that has a circular window portion is formed on the first plate-shaped member 2. The first plate-shaped member 2 is exposed in the circular window portion 4a. The LED chips 1 are mounted inside the circular window portion 4a. A plurality of (in Fig. 12, twenty-one of) the LED chips 1 are arranged in a square matrix shape. The square matrix shape refers to an arrangement where the LED chips 1 are arranged in locations defined by lines that forms a grid shape, but is not limited to an arrangement where the whole shape of the LED chips 1 forms a rectangle. According to the present invention, since a water-cooling system discussed below can achieve high cooling efficiency, the LED chips 1 as heat generating elements can be spaced at a small interval 11 from each other to mount them at high density.

[0150] Fig. 13 is a cross-sectional view schematically showing the structure of the heat sink of the semiconductor apparatus according to this embodiment. For ease of explanation, this Figure shows components, with being separated from each other. The heat sink is composed of the first plate-shaped member 2 and the second plate-shaped member 3. The first plate-shaped member 2 has a first surface 21 and a second surface 22. The second plate-shaped member 3 has a first surface 31 and a second surface 32. The LED chips 1 as the heat generating elements are mounted on the first surface 21 of the first plate-shaped member 2. The second surface 22 of the first plate-shaped member 2 and the first surface 31 of the second plate-shaped member 3 are opposed to each other. A portion that is interposed between the two surfaces serves as a flow path where the cooling fluid flows. As shown in an enlarged partial view of Fig. 13, a plurality of protruding portions 25 are formed on the second surface 22 of the first plate-shaped member 2. The protruding portions 25 increase the contact area between the cooling fluid and the first plate-shaped member 2. Accordingly, it is possible to efficiently dissipate heat conducted from the LED chips 1 to the first plate-shaped member 2. In addition, the protruding portions 25 that are formed on the first plate-shaped member 2 serve to vary the flowing direction and flowing velocity of the cooling fluid. Accordingly, it is possible to improve heat dissipation efficiency. The plate-shaped member that composes the heat sink is preferably formed of a high thermal conductive material. It is preferable that the plate-shaped member is formed of a copper group thin material that is made of copper (Cu) as a base material. It is most preferable that the plate-shaped member is formed of oxygen-free copper. As discussed later, in the case where the plate-shaped members are bonded with each other with a eutectic material, this provides a high degree of flexibility in selection of material of the plate-shaped members. Particularly, in the case where metal materials containing Au coat the whole attachment surface of each of the plate-shaped members, when at least one of the metal materials containing Au is a eutectic material with low melting point (for example, melting point of 500°C or less), it is not necessary to take in consideration of corrosion resistance against cooling fluid. This provides a higher degree of flexibility in selection of material of the plate-shaped members. As a result, it is possible to employ a material with a coefficient of thermal expansion substantially equal to a substrate material of the semiconductor element that is mounted on the plate-shaped member (particularly, the first plate-shaped member) as a material thereof. Accordingly, it is possible to reduce strain that is applied to the semiconductor element when the semiconductor element is mounted. For example, in the case where the semiconductor element is formed on a supporting substrate formed of CuW, and so on, the first plate-shaped member is formed of the same CuW. In this case, a metal material containing Au (Au, AuSn, AuSi, or a material with laminated layers of them) coats the attachment surface (= the second surface).

[0151] The protruding portions 25 are formed on the second surface 22 of the first plate-shaped member 2, thus, the asperity pattern is formed. In this embodiment, the protruding portion 25 that has a circle shape as viewed in a plan view (i.e., cylindrical shape) is illustrated. However, the asperity pattern can be formed in a streak shape, a rectangular shape, a stripe shape, a grid shape, and so on. The asperities that are formed on the second surface 22 of the first plate-shaped member 2 preferably have the height of a stepped part of not less than 100 μm to not more than 500 μm, more preferably not less than 100 μm to not more than 300 μm.

[0152] In the heat sink according to the present invention, it is preferable that the ratio between a contact area (a) of the heat generating element in the first surface of the first plate-shaped member and the surface area (b) of the second surface that is opposed to the contact region of the heat generating element is $0.2 \leq (a/b) < 1$, more preferably $0.2 \leq (a/b) < 0.5$. In order to satisfy this requirement, asperities can be formed on the second surface 22 of the first plate-shaped member 2. The LED chips 1 as heat generating elements have a chip size of about 100 μm to 10 mm square. In the case where asperities are formed on the second surface that is opposed to the first surface on which a plurality of heat generating elements 1 as such are mounted, recessed parts and/or protruding parts that are formed on the second surface preferably have a size with a width of not less than 10 μm to not more than 1000 μm.

[0153] The first plate-shaped member 2 and the second plate-shaped member 3 according to a preferred form will be described with reference to Figs. 4 to 6. Figs. 14(a) to (c) show the first plate-shaped member 2 according to the preferred form. Figs. 15(a) to (c) show the second plate-shaped member 3 according to the preferred form. Figs. 16(a) and (b) show the plate-shaped members combined with each other shown in Figs. 14 and 15.

[0154] The first plate-shaped member 2 according to the preferred form is now described. As shown in Figs. 14(a) to (c), a circular recessed section 24 that forms the flow path of the cooling fluid is formed in a substantially central part of the second surface 22 of the first plate-shaped member 2. In this embodiment, the depth of the circular recessed section

24 equals to the height of the flow path where the cooling fluid flows. It is preferable that the depth of the circular recessed section 24 is not less than 10 μm and not more than 500 μm, and more preferably 100 μm and 300 μm. The reason is that, if the height of the flow path is too low, processing is difficult, and additionally the resistance of cooling water that flows in the flow path increases. On the other hand, if the height of the flow path is too high, the cooling fluid flows even in a location that is distant from the bottom surface of the recessed section 24 as a heat dissipation surface. This causes excess circulation of a fluid that serves for cooling.

[0155] The protruding portions 25 as a heat dissipation fin are regularly arranged in the bottom surface of the circular recessed section 24. Each of protruding portions 25 preferably has a height that equals to the depth of the circular recessed section 24 or less. In this embodiment, the height of the protruding portion 25 equals to the depth of the circular recessed section 24 (= height of the flow path). In this case, when the first plate-shaped member 2 and the second plate-shaped member 3 are attached to each other, the protruding portions 25 serve as supports, thus, mechanical strength of the heat sink is improved. In this construction, the upper surfaces of the protruding portions 25 can be bonded with the surface of the second plate-shaped member 3. This bonding can increase a bonded area between the first plate-shaped member 2 and the second plate-shaped member 3. Accordingly, mechanical strength of the heat sink is further improved. On the other hand, in the case where the height of the protruding portion 25 is smaller than the depth of the circular recessed section 24 (= height of the flow path), cooling fluid can be in contact with the upper surfaces of the protruding portions 25. Accordingly, heat dissipation efficiency is improved. In addition, the protruding portions 25 can be formed on the first surface 31 of the second plate-shaped member 3, and the upper surfaces of the protruding portions 25 can be attached to the second surface 22 of the first plate-shaped member 2. In this case, since the protruding portions 25 formed unitarily with the second surface 22 of the first plate-shaped member 2 in terms of thermal conduction and a mechanical structure, it can be considered that the protruding portions are formed on the second surface 22 of the first plate-shaped member 2. Screw holes 23 are formed at four corners of the first plate-shaped member 2.

[0156] The second plate-shaped member 3 according to the preferred form is now described. As shown in Figs. 15 (a) to (c), the second plate-shaped member 3 is provided with the inlet 36a as a through hole for admission of the fluid, and the outlet 36b as a through hole for ejection of the fluid that are formed therein. The second plate-shaped member has a fan-shaped recessed section 34a that extends from the inlet 36a toward the center part of the second plate-shaped member 3 substantially in a fan shape on the first surface 31. The fan-shaped recessed section 34a composes a guide portion that guides the cooling fluid from the inlet 36a to an inlet part of the flow path. The fan-shaped recessed section 34a has an arc-shaped periphery 37a that is located near the center part of the plate-shaped member. The arc-shaped periphery 37a and together with a periphery 24a of the circular recessed section 24 shown in Fig. 14 compose the inlet part of the flow path. A plurality of support pillars 35a are formed on the bottom of the fan-shaped recessed section 34a. The support pillars 35a are radially arranged along a direction that the fluid flows. The support pillars 35a have a height that their upper surfaces lie in the same plane as the first surface 31 and first surface 1 of the second plate-shaped member. Their upper surfaces serve as bounded surfaces when the first plate-shaped member 2 and the second plate-shaped member 3 are attached to each other. The support pillars 35a are formed as discussed above, thus, mechanical strength of the heat sink is improved, and additionally the cooling fluid tends to flow uniformly in the whole of flow path.

[0157] The outlet 36b has similar construction. That is, a fan-shaped recessed section 34b extends from the outlet 36b toward the center part of the plate-shaped member substantially in a fan shape. The fan-shaped recessed section 34b composes a guide portion that guides the cooling fluid from an outlet part of the flow path to the outlet 36b. The fan-shaped recessed section 34b has an arc-shaped periphery 37b that is located near the center part of the plate-shaped member. The arc-shaped periphery 37b and together with a periphery 24b of the circular recessed section 24 shown in Fig. 14 compose the outlet part of the flow path. A plurality of support pillars 35b are formed on the bottom of the fan-shaped recessed section 34b. In addition, screw holes 33 are formed at four corners of the second plate-shaped member 3, and are aligned with the screw holes 23 that are located at the four corners of the first plate-shaped member 2, thus, the plate-shaped members can be positioned.

[0158] Figs. 16(a) and (b) show the combination of the first plate-shaped member 2 and the second plate-shaped member 3. As shown in Figs. 16(a) and (b), the circular recessed section 24 that is formed in the second surface 22 of the first plate-shaped member 2 forms a circular cooling flow path between the second surface 22 of the first plate-shaped member 2 and the first surfaces 31 of the second plate-shaped member. An inlet part 13 of the circular cooling flow path is formed between the arc-shaped periphery 37a of the fan-shaped recessed section 34a that is formed in the second plate-shaped member 3, and the periphery 24a of the circular recessed section 24 of the first plate-shaped member 2. The inlet part 13 has an arc shape. Similarly, an outlet part 14 of the circular cooling flow path is formed between the arc-shaped periphery 37b of the fan-shaped recessed section 34b that is formed in the second plate-shaped member 3, and the periphery 24b of the circular recessed section 24 of the first plate-shaped member 2. The outlet part 14 has an arc shape. Need less to say, the arc-shaped periphery 37a or 37b is located in an inner side relative to the periphery 24a or 24b of the circular recessed section 24 of the first plate-shaped member 2. The fan-shaped recessed section 34a that is formed in the second plate-shaped member 3 forms a guide that guides the cooling fluid from the inlet 36a to the inlet part 13 of the flow path between the second plate-shaped member 3 and the second surfaces 32 of the first plate-shaped member. Similarly, the fan-shaped recessed section 34b that is formed in the second plate-shaped member 3 forms a guide that guides the cooling fluid from the outlet part 14 of the flow path to the outlet 36b between the second plate-shaped member 3 and the second surfaces 22 of the first plate-shaped member.

[0159] In the heat sink shown in Fig. 16, the cooling fluid flows as discussed below. First, the cooling fluid that is admitted from the inlet 36a flows toward the center part of the heat sink so as to extend along the guide formed by the fan-shaped recessed section 34a. When reaching the periphery 37 of the fan-shaped recessed section 34a, the cooling fluid flows into the inlet part 13 of the flow path defined by the periphery 37a of the fan-shaped recessed section 34a, and the periphery 24a of the circular recessed section 24. Since the inlet part 13 of the flow path has an arc shape, a part of flow directing toward the center part of the heat sink enters the flow path so as to extend around the periphery part of the heat sink. Accordingly, the cooling fluid tends to flow uniformly in the whole of flow path. Additionally, water pressure distribution of the cooling fluid tends to have contour lines that are perpendicular to the fluid flow. Therefore, it is possible to provide a cooling effect over the whole of flow path that flatly extends, and to suppress characteristic variations of the mounted LED chips 1 due to heat.

[0160] The fluid that enters from the inlet part 13 of the cooling flow path repeatedly goes around in an S-shape at the protruding portions 25, and directs toward the outlet part 14 of the flow path. That is, the protruding portions 25 are arranged apart from each other in a bended manner such that line segments that successively connect the protruding portions 25 closest to each other repeatedly change their direction. Accordingly, the fluid flows in the flow path such that the fluid that strikes the protruding portions 25 repeatedly goes around in an S-shape at the protruding portions 25 from a central inlet part 13 to a central outlet part 14. In other words, in the case the protruding portions 25 are regarded as a two-dimensional arrangement consisting of 1 st column, 2nd column, ···, and n-th column, the protruding portions 25 in the n-th column are arranged apart at an interval of a half pitch from the protruding portions 25 in the (n-1)-th column in the up-and-down direction. Thus, each protruding portion 25 is located at the center of a square that are defined by the four adjacent protruding portions 25. As discussed above, the protruding portions 25 are arranged such that the fluid repeatedly goes around in an S-shape at the protruding portions 25, thus, this aids heat exchange between the cooling fluid and the first plate-shaped member. Accordingly, a heat dissipation effect is further improved.

[0161] When the cooling fluid reaches the outlet part 14 of the flow path after flowing through the flow path, it is ejected from the outlet 36b through the guide formed by the fan-shaped recessed section 34b. In this case, since the outlet part 14 of the flow path has an arc shape, the fluid that flows from the periphery of the flow path flows out toward the center part of the outlet part so as to go along its arc. Accordingly, similarly to the aforementioned case, the cooling fluid tends to flow uniformly in the whole of flow path. Additionally, water pressure distribution of the cooling fluid tends to have contour lines that are perpendicular to the fluid flow. Therefore, it is possible to provide a heat dissipation effect over the whole of flow path that flatly extends, and to suppress characteristic variations of the mounted LED chips 1 due to heat. In addition, the shape of the flow path that is formed in the plate-shaped member is not limited to the shape shown in Figs. 14 and 15.

[0162] In this embodiment, it is preferable that the protruding portion 25 formed in the flow path is located at a particular position relative to the LED chip 1 as the heat generating element. Figs. 17(a) and (b) schematically show an arrangement between the LED chip 1 and the protruding portion 25 in the case where the LED chips 1 are arranged in a square matrix shape. As mentioned above, in thermal transport where heat is dissipated from the heat surface, the heat from the heat generating element such as LED chip is conveyed in the heat while spreading at 45° relative to the thickness direction. That is, as shown in Fig. 16(b), the heat generated by the LED chip 1 transfers so as to spread at 45° when transferring in the plate-thickness direction in the first plate-shaped member 2. For this reason, in the case where chips are mounted at high density such that an interval between the chips is not larger than the chip width (more specifically, not more than a half the chip width) for example, heat generated by two LED chips adjacent to each other is overlapped during conveyed in the thickness direction of the first plate-shaped member. This causes thermal interference and relatively increases heat density in a location corresponding to the interval 11 between the LED chips. Accordingly, it is preferable that some of the plurality of the protruding portions 25 are formed in locations corresponding to the intervals 11 between the LED chips 1. The reason is that heat density in a part where the protruding portion 25 is formed can be reduced. That is, in the case where the protruding portion 25 is formed, since a surface area per unit of projected area of the first plate-shaped member 2 increases, heat density in a surface in contact with the cooling fluid (= the second surface 22 of the first plate-shaped member 2) can be reduced. Therefore, even in the case where semiconductor elements as heat generating elements such as LED chips are mounted at high density and cause mutual thermal interference, it is possible to suppress heat distribution and to provide high efficient cooling.

[0163] For similar reason, it is preferable that the protruding portion 25 is located in a location corresponding to the substantially center of each LED chip 1. The reason is that, generally, a semiconductor light emitting element such as LED chip largely generates heat in its central part. In this embodiment, as shown in Fig. 17(a), the protruding portions 25 are formed so as to be positioned at the center and four corners of the LED chip 1. The protruding portions 25 that are formed at the four corners of the LED chip 1 are positioned at the center of the interval 11 between the LED chips 1. That is, the protruding portion 25 that is formed at a corner of one LED chip 1 is formed so as to overlap three adjacent

LED chips 1. The protruding portions 25 are positioned as discussed above, thus, the heat distribution produced inside the LED chips 1, and the heat distribution produced by heat interference between the LED chips 1 are suppressed. Accordingly, it is possible to efficiently dissipate heat. In addition, the LED chips 1 may be positioned at the centers of four edges of the rectangular LED chip 1 instead of the four corners of the rectangular LED chip 1. In this case, one protruding portion 25 overlaps two adjacent LED chips 1. Additionally, it is preferable that the center of protruding portion 25 is positioned on the interval 11 between the LED chips 1.

[0164] It is preferable that the plate-shaped members that compose the heat sink are attached to each other with a eutectic material. Attachment of the plate-shaped members to each other with a eutectic material provides excellent heat conductivity and electric conductivity from the first plate-shaped member 2 to the second plate-shaped member 3. Additionally, it is possible to provide high heat resistant bonding. Excellent heat conductivity between the first plate-shaped member 2 and the second plate-shaped member 3 provides an advantage in terms of construction of the heat sink with this combination. In addition, excellent electric conductivity between the first plate-shaped member 2 and the second plate-shaped member 3 provides an advantage in the case where the heat sink with this combination serves as a lead.

[0165] It is preferable that a eutectic material is formed the whole of attachment surface, i.e., the whole of the second surface 22 of the first plate-shaped member 2 and the whole of the first surface 31 of the second plate-shaped member 3. Accordingly, the eutectic material can protect the surface of the plate-shaped member from corrosion due to the fluid, and so on. For example, although copper, or the like, with high heat conductivity is a preferable material as a plate-shaped member, copper easily causes electrolytic corrosion due to the cooling water, or the like. Coating of high corrosion resistant eutectic material (e.g., an alloy containing Au) on the whole of attachment surface can provide high reliable heat sink. A eutectic material may coats the surface of one of plate-shaped members, and a metal layer may be formed on an attachment surface of the other plate-shaped member. The metal layer is formed on the plate-shaped member, and thus protects the surface of the plate-shaped member. Additionally, it is possible to easily provide connection between the metal layer and the eutectic material. It is preferable that the eutectic material is an adhesive material that contains at least one material selected from the group consisting of AuSn, AuSi, SnAgBi, SnAgCu, SnAgBiCu, SnCu, SnBi, PbSn, and In. The metal layer is not specifically limited as long as having wettability in a relationship of the eutectic material as a bonding material. An alloy containing Au (e.g., AuSn), and Au or a laminated-layer material containing Au can be given be give as preferable combination of the eutectic material, and the metal layer.

[0166] The heat sink according to present invention can be provided with two or more heat generating elements 1 mounted in an array shape thereon. Using the heat sink according to present invention provides sufficient heat dissipation even in the case where a plurality of heat generating elements are mounted. Additionally, it is possible to suppress the entry of cooling fluid, peel-off of the plate-shaped member due to the entry, and so on. The heat generating elements that are formed in an array shape on the same surface of the heat sink can be electrically connected to each other in parallel and/or in series.

[0167] In addition, it is preferable that the heat generating element is a semiconductor element that has a first conductivity type layer and a second conductivity type layer. In the case where a first conductivity type is an n type, a second conductivity type is a p type, and vice versa. In this embodiment, the first conductivity type layer is electrically connected to the heat sink, and the second conductivity type layer is electrically connected to a metal member that is formed above the heat sink so as sandwich an insulating layer between them.

[0168] The heat sink according to present invention can be provided with two or more heat generating elements 1 mounted in an array shape thereon. Using the heat sink according to present invention provides sufficient heat dissipation even in the case where a plurality of heat generating elements are mounted. Additionally, it is possible to suppress the entry of a cooling material, peel-off of the plate-shaped member due to the entry, and so on. The heat generating elements that are formed in an array shape on the same surface of the heat sink can be electrically connected to each other in parallel and/or in series.

[0169] As shown in Fig. 18, the semiconductor apparatus according to the present invention has a heat sink 40. For example, the cooling fluid flows inside the heat sink 40 through an inlet 42 and an outlet 44 that are provided on the outside surface of the heat sink 40. Heat that is generated by semiconductor elements 46 as the heat generating elements is excellently dissipated the cooling fluid that flows inside the heat sink 40. The heat sink 40 is a laminated plate-shaped member that is formed of two or more plate-shaped members attached to each other, for example. The plate-shaped members are firmly bonded with each other with a eutectic material or a metal layer with wettability provided thereon. Accordingly, cooling water does leak inside the heat sink 40. In the case where a semiconductor light emitting element, particularly a semiconductor laser is used as the heat generating element according to the present invention, it is possible to provide a high-power laser light source apparatus that emits laser light in a short wavelength range of 500 nm or less. Needless to say, this embodiment can be applied to the case where a light emitting diode, a photoreceptor element, and so on, are used as the heat generating element.

[0170] A unit module type light source apparatus with LED light sources (Fig. 18) can be given as an example of the semiconductor apparatus o the construction according to the present invention. The outline of light source apparatus has the heat sink 40, a fastener 50 for fastening it, and screws 48. In addition, a member that connects an inlet and an outlet of the heat sink 40 to and an inlet 42 and an outlet 44 of the fastener 50 without leakage may be used between the heat sink 40 and the fastener 50. This member can be made of resin or metal, for example. The aforementioned unit module type light source apparatus with LED light sources can have an appearance of a quadrangle as shown in Fig. 18, or a triangle and as shown in Fig. 19. In Figs. 18 and 19, wiring for supplying electric power from a power supply is omitted for the sake of brevity.

[0171] In the case where the unit module type light source apparatuses with LED light sources of the aforementioned construction are arranged, it is possible to an ultra high-power module type light source apparatus. Fig. 20 shows an ultra high-power module type light source apparatus. When unit module type light source apparatuses with LED light sources 52 have an appearance of a quadrangle as shown in Fig. 20, the light source apparatuses are arranged in an array alignment or in a matrix alignment to provide a higher-power light source. In this case, it is preferable that inlets and outlets of cooling fluid of the module type light source apparatuses 52 are communicated to each other in series or in parallel. That is, the inlets or outlets of the module type light source apparatuses 52 can be communicated to each other. Alternatively, the outlet of one of the module type light source apparatuses 52 can be repeatedly connected to the inlet of a subsequent unit module type light source apparatus. When the aforementioned unit module type light source apparatuses with LED light sources 52 have an appearance of a triangle as shown in Fig. 21, they can be circularly arranged such that their edges successively overlap one another. Thus, the whole shape of them forms a polygon. In this arrangement, it is possible to provide construction of a higher-power light source with a small area. In addition, the ultra high-power module type light source apparatus can have a member that connects inlets and outlets between the unit module type light source apparatuses that compose the ultra high-power module type light source apparatus. This member can be made of resin or metal, for example. In this case, in serial connection where the unit module type light source apparatuses are arranged in an array shape, a matrix shape, or a circular shape, even if high pressure is required, it is possible to prevent leakage.

EXAMPLES

[0172] Examples of the light emitting device according to the present invention are described. However, the present invention is not limited to these examples. Additionally, the sizes and the arrangement relationships of the members in each of drawings are occasionally shown larger exaggeratingly for ease of explanation. In this specification, in light emitting devices of the following examples, a material, a shape, and an arrangement of conductive wiring and a conductive wire that supply electric power to a semiconductor light-emitting element can have various forms. In this specification, their description and illustrations are occasionally omitted for sake of brevity.

[0173] [Example 1]

Fig. 1 shows a cross-sectional view schematically showing a light emitting device according to this example. A light emitting device 100 according to this example has a heat dissipation member 102 that includes a flow path 105 of a refrigerant, and a support member 103 that is provided a recessed portion 106 on which a plurality of semiconductor light emitting elements 104 are mounted to be arranged in a matrix shape. In addition, a light conversion member 101 is applied on a surface of the aforementioned heat dissipation members 102 where light emitted by a light emitting device 100 is observed.

The semiconductor light emitting element 104 according to this example has a light-emission peak wavelength of 365 nm. The light conversion member 101 contains a material that is mixed with a phosphor suitably selected from the aforementioned phosphors to emit white range light. The heat dissipation member 102 is made of a quartz glass, and has an inlet and an outlet (not shown) for roviding the refrigerant to the flow path 105. The support member 103 is formed of a plate-shaped member of oxygen-free copper on which the recessed portion 10 is formed by processing.

The light emitting device 100 formed as discussed above is attached to a water cooling device, and pure water as the refrigerant is provided to the flow path inside the light emitting device through the inlet.

While cooling water is circulated in the light emitting device according to the present invention, electric power is supplied for 60 sec such that the light emitting element emits light at light density of 4.9 W/cm^2. Reduction of output is not observed. The temperature of the light conversion member for light density of the light emitting element, and the light output of the light emitting device are measured. The temperature of the light conversion member is measured by a thermistor that is inserted to the light conversion member. Table 1 shows the result. Fig. 5(a) schematically shows the case where electric power is supplied to the light emitting device for 60 sec. Fig. 5(b) schematically shows time variation of relative output of the light emitting device according to this example. As is evident from this embodiment, the light density of light from the light emitting element can be 3.0 W/cm^2 or more, and the temperature of the light conversion member can be suppressed to at least 200°C or more, preferably 120°C, more preferably 100°C or less.

According to the light emitting device of this embodiment, even in the case where light from the light emitting element that excites the phosphor has a short wavelength and is emitted at high density as excitation light, it is possible to suppresses self-heat generation of the phosphor to a negligible extent, and to keep the light conversion efficiency optimized. Therefore, it is possible to provide a light emitting device capable of emitting light at high luminance.

[0174] [Example 2]

A light emitting device is configured similar to the example 1 except that a refrigerant is not provided to a flow path. In this light emitting device, light emitting elements emitting ultraviolet light are arranged in a matrix shape in a recessed portion of a first heat dissipation member. A light conversion member that contains a phosphor material so as to emit white range light is located directly above the light emitting elements at a distance of about 2 mm. The light emitting element has a light emission peak wavelength of 365 nm. The phosphor is suitably selected from the aforementioned phosphors to emit white range light and is mixed. The heat dissipation ember is made of a quartz glass material. The light conversion member is applied to a surface of the quartz glass in a side where light is observed. The temperature of the light conversion member is measured by a thermistor that is inserted to the light conversion member. The light density of the light emitting element, the temperature of the light conversion member for electric power to the light emitting element, and the light output of the light emitting device are measured. The following table shows the result. Fig. 5(a) schematically shows the case where electric power is supplied to the light emitting device for time of 60 sec. As for the respective light densities of light emitting element, Fig. 5(b) schematically shows time variation of relative light output of the light emitting device. As for the light densities of light emitting element, Fig. 5(c) schematically shows time variation of the temperature of the light conversion member.

[0175]

TABLE 1

Light Density [W/cm^2]	Electric Power [W]	Temp of Light Conversion Member [°C]
1.5	15	About 60
2.7	30	About 85
4.9	70	About 120

When the electric power is 15 W, the temperature of the light conversion member is about 60°C, and the light output is sufficiently stable, as shown in Fig. 5(b). When the electric power is 30 W, the temperature of the light conversion member is about 85°C, and the light output of white light as a second light slightly decreases at first but became sufficiently stable. When the electric power is 70 W, the temperature of the light conversion member reaches about 120°C at 60 sec after the electric power is supplied. The output light of the light emitting device decreases to about 75% of the initial output after the electric power is supplied, but shows a tendency to be stable at a certain output.

[0176] [Example 3]

Fig. 2 shows a cross-sectional view schematically showing a light emitting device 200 according to this example. A heat dissipation member 202 according to this example is formed of a plate-shaped metal material that has a plurality of through holes arranged in a shape as viewed from a side of the light emitting device 200 where light is observed. A light conversion member 201 is formed on a surface in a side where light from the semiconductor light emitting element 104 is incident, the through holes, and a surface where light is observed in the heat dissipation member 202. Thus, the heat dissipation member 202 extends in a net shape inside the light conversion member 201. As viewed from a side where light is observed, the heat dissipation member 202 or the periphery of the light conversion member 201 is thermally connected to the support member 103. The light emitting device is configured similar to the example 1 except the above construction. According to the construction of this example as discussed above, the light emitting device has effects substantially similar to the example 1, and additionally aids heat dissipation from the central part of the light conversion member to the periphery. Thus, the light emitting device provides high power.

[0177] [Example 4]

Fig. 3 shows a cross-sectional view schematically showing a light emitting device 300 according to this example. Both a light conversion member 301 and a heat dissipation member 302 according to this example are provided on the upper surface side where light from the light emitting device 300 is observed in the upper and lower surfaces of a transparent member 303. The transparent member 303 is formed of a plate-shaped material that passes light from at least the semiconductor light emitting element 104, and is made of glass, transparent resin, or the like, as its material, specifically. The light conversion member 301 is dimensioned to an area where the light that passes through the aforementioned transparent member 303 is incident, in other words, it is dimensioned to the size of an opening of the recessed portion 106. The heat dissipation member 302 has the flow path of a refrigerant therein, and is formed so as to surround the rim of the light conversion member 301. The flow path of the refrigerant inside the heat dissipation member 302 is formed so as to surround the light conversion member 301. As viewed from a side where light is observed, the periphery of the transparent member 303 may contain filler in a portion that is in contact with at least the support member 103 in order to improve heat conductivity. The light emitting device is configured similar to the example 1 except the above construction.

According to the construction of this example as discussed above, the light emitting device has effects substantially similar to the example 1 without that the heat dissipation member affects the optical characteristics of light that outgoes from the light emitting device. Thus, the light emitting device provides higher power.

[0178] [Example 5]

Fig. 4 shows a cross-sectional view schematically showing a light emitting device 400 according to this example. The light emitting device 400 according to this example has a curve-shaped heat dissipation member 402 in an opening orientation of the recessed portion 106 of the support member 103 on which the semiconductor light emitting element 104 is mounted. A light conversion member 401 is applied an inner wall surface of the heat dissipation member 402 (a surface where light from the light emitting element 104 is incident). An end of the heat dissipation member 402 is thermally connected to the support member 103. Another end is spaced away from the support member 103 so as to allow light emitted by the light emitting device to pass between them. According to this construction, light from the semiconductor light emitting element 104 (as illustrated by dotted lines in the Figure, for example) is incident on the light conversion member. Then, light with a wavelength converted by a phosphor is reflected by the inner wall surface of the heat dissipation member 402 and is radiated from the light emitting device 400 (as illustrated by solid lines in the Figure, for example). The light emitting device is configured similar to the example 1 except the above construction. According to this example, the light emitting device has effects substantially similar to the example 1. Additionally, the light emitting device radiates light with the wavelength converted by the phosphor toward a desired direction.

[0179] [Example 6]

Fig. 6 shows a perspective view and a partial cross-sectional view schematically showing a light emitting device according to this example. Fig. 7 is a perspective view schematically showing components of the light emitting device according to this example of the present invention. Fig. 8 is a cross-sectional view of the light emitting device of Fig. 6 as seen along the line X-X.

A light emitting device 100 according to example has a first heat dissipation member 115 with a first flow path 112, and a supporting substrate 108 that supplies electric power to light emitting elements 104. They are laminated so as to sandwich an insulating member 107. A second heat dissipation member 109 with a second flow path 113 is laminated on the aforementioned supporting substrate 108. The light conversion member 101 containing a phosphor is coated on a main surface in a side where light is observed of the second heat dissipation member 109. An inlet for admission of a refrigerant to the aforementioned flow path, and an outlet for ejection of the refrigerant external of the light emitting device through the aforementioned flow path are formed in a main surface side of the first heat dissipation member 115, in other words, a side where the light emitting device 100 is mounted. The insulating member 107 and the supporting substrate 108 have through holes in the principle side. The through holes are opposed to the aforementioned inlet and outlet, and serves as third flow paths 110 for communicating the aforementioned first and second flow paths 112 and 113. In addition, a through hole that surrounds mounted semiconductor light emitting elements is formed in the supporting substrate 108. The through hole has an inner wall surface that is tapered so as to reflect light from the light emitting elements toward a side where the light is observed.

A plurality of the light emitting elements 201 are arranged in a matrix shape in a recessed portion of the first heat dissipation member. The light conversion member containing the phosphor to provide white range light is provided on the second heat dissipation member. The light emitting element according to this example has a light emission peak wavelength of 365 nm. The phosphor is suitably selected from the aforementioned phosphors to provide white range light and is mixed. The second heat dissipation member is made of a quartz glass material. The light conversion member is applied to a surface of the quartz glass in a side where light is observed. A formation method of the light emitting device according this example is now described.

First, the first heat dissipation member 115 that cools the light emitting elements is formed. As shown in Fig. 7, material plates of oxygen-free copper are processed to form the first and second plate-shaped members 115a and 115b. The first and second plate-shaped members have 200 μm. Fastening screw holes for are formed at four corners of the first plate-shaped member 115a. The through holes that serve as side walls of the third flow paths are formed in a surface that is opposed to the principle of surface the semiconductor light emitting elements are mounted. After the screw holes are formed, as shown in Fig. 2, at the four corners, asperities that form the first flow path 112, the inlet for admission of the refrigerant into the light emitting device, and the outlet for ejection of the refrigerant external of the light emitting device are formed, In addition, main surfaces of the first and second plate-shape members that are opposed to each other are provided with Au and/or an alloy layer of Au and Sn formed thereon. After that, the first and second plate-shape members are attached to each other by thermal treatment of 300 to 400°C in a nitrogen atmosphere to form the first heat dissipation member with the laminated plate-shaped members. The aforementioned asperities define space that forms the first flow path between the first and second plate-shape members.

Subsequently, the light conversion member is coated to form the second heat dissipation member 109 for cooling the light conversion member itself. The second heat dissipation member 109 is made of a material that has transparency for at least light of a main wavelength of the semiconductor light emitting element, preferably of light of the light emitting element and the phosphor. For example, the two plate-shaped members 109a and 109b are made of synthetic quarts

glass and transparent resin. The asperities, inlet, and outlet are formed in a main surface of at least one of the plate-shaped member. After that, two plate-shaped members are attached to each other to form the second heat dissipation member 109.
In addition, the first heat dissipation member 115 for cooling the light emitting elements to be mounted, the insulating member 107, and the second member on which the light conversion member is coated are successively laminated. In this case, the through holes are previously formed in the insulating member, and the openings of components are positioned such that the inlets and outlets of the first and second heat dissipation members are aligned, respectively. The upper and lower surfaces of the insulating member 107 are electrically insulated. Screw holes corresponding to the aforementioned the screw holes are provided in the insulating member 107. The diameter of the openings of the through hole provided in the insulating member 107 are dimensioned to be smaller than the diameters of the inlet and outlet of the first or second heat dissipation member, and O-rings are preferably provided to the openings. The O-rings are ring-shaped members made of an elastic material such as rubber and silicone resin, and are inserted into the through holes. This construction can prevent leakage of the refrigerant from the light emitting device. As discussed above, the support member on which the semiconductor light emitting elements are mounted is formed.
The semiconductor light emitting elements are mounted on the first heat dissipation member 115 with a conductive adhesive agent. The light conversion member 101 with the phosphor bounded with a transparent resin is coated on an upper surface in a side where light is observed of the second heat dissipation member 109. The semiconductor light emitting elements are mounted with Au-Sn as an adhesive agent in the recessed portion 111 that is formed by the first heat dissipation member and the supporting substrate 108. In this case, the eutectic temperature of Au-Sn when the semiconductor light emitting elements are mounted is set lower than the eutectic temperature of Au-Sn when the plate-shaped members consisting principally of the aforementioned copper are bonded. This can prevent the plate-shaped members from peeling off.
The light emitting device 100 formed as discussed above is attached to a water cooling device, and pure water as the refrigerant is provided to the flow path inside the light emitting device through the inlet. As shown in Fig. 8, pure water that is continuously supplied to the light emitting device through the inlet separately flows in the first flow path 112 and in the second flow path through the third flow path 110, for example. The pure water that separately flows meets again in the periphery of the outlet and is elected external of the light emitting device 100. In the case of circulation of pure water inside the light emitting device, since components are bonded to each other with Au-Sn as an adhesive agent, and the light emitting device according to this example has the O-rings as discussed above, the refrigerant does not leak from a heat sink.
While cooling water is circulated in the light emitting device according to the present invention, electric power is supplied for 60 sec such that the light emitting element emits light at light density of 4.9 W/cm^2. Reduction of output is not observed. The temperature of the light conversion member for light density of the light emitting element, and the light output of the light emitting device are measured. The temperature of the light conversion member is measured by a thermistor that is inserted to the light conversion member. As is evident from this example, the light density of light from the light emitting element can be 3.0 W/cm^2 or more, and the temperature of the light conversion member can be suppressed to at least 200°C or more, preferably 120°C, more preferably 100°C or less.
According to the light emitting device of this embodiment, even in the case where light from the light emitting element that excites the phosphor has a short wavelength and is emitted at high density as excitation light, it is possible to suppresses self-heat generation of the phosphor to a negligible extent, and to keep the light conversion efficiency optimized. Therefore, it is possible to provide a light emitting device capable of emitting light at high luminance.
[0180] [Example 7]
Material plates of oxygen-free copper with a thickness of 200 μm are processed to form first and second plate-shaped members as shown in Figs. 14 and 15. Screw holes are formed at four corners of the first plate-shaped member. Asperities are formed on a second surface that is opposed to a first surface on which a heat generating element is formed (Fig. 14). Screw holes are formed at four corners of the second plate-shaped member. In addition, an inlet for admission of a fluid and an outlet are formed (Fig. 15). Formation surfaces of these members are provided with an Au layer and/or AuSn layer formed thereon. After that, the members are attached by thermal treatment at 300°C to 400°C in an N_2 gas atmosphere to form a laminated plate-shaped member. The heat generating element is mounted in the laminated plate-shaped member with an adhesive material such as AuSn. In this case, the weight ratio of AuSn is controlled such that the eutectic temperature when the heat generating member is mounted is low compared with the eutectic temperature in the processing on a copper thin plate. This can suppress peel-off of the heat sink when the heat generating element is bonded. In the state where the heat sink with the heat generating element formed thereon is attached to a water cooling device as discussed above, the fluid is not leaked from the heat sink when the fluid such as pure water is circulated.
[0181] [EXAMPLE 7-1]
A heat sink is composed of a laminated plate-shaped member having the aforementioned first plate-shaped member with a second surface on which asperities is formed by chemical etching, and so on. Twenty-one of LED elements formed of a nitride semiconductor with 1 mm square are mounted. Thus, a prototype LED light source with an opening diameter

of about 8 mm is produced. A recessed part in the asperities has a width of 200 μm and a depth of 200 μm. A protruding part has a width of 800 μm. The I-L characteristic of one typical element in the twenty-one of elements that composes the LED light source, and the I-L characteristic of one element that is cooled by a conventional passive cooling means are observed. In this observation, in the case of the passive cooling means shown by non-solid circular points, its line is deviated from linearity form 0.3 A to 0.5 A as shown in Fig. 22. On the contrary to this, in the active cooling means according to this example, as shown by a solid line, even in the case of the semiconductor apparatus with the twenty-one LED elements are mounted, it is observed that it has linearity even in the range beyond 0.5 A. As shown in Fig. 23, the semiconductor apparatus with the twenty-one LED elements with 1 mm square are mounted thereon provides light output of over 5 watts. Even in consideration of thermal interference in the case of an interval between the elements of about 200 μm, although the elements are mounted at high density, the high brightness LED light source with excellent linearity is provided.

[0182] [EXAMPLE 7-2]

A semiconductor apparatus has twenty-one LED elements that are mounted on a heat sink according to the present invention. The semiconductor apparatus is driven at a constant current while pure water as a circulation cooling medium as a fluid is circulated (conditions of temperature 25°C, and flow rate 0.4 Umin). Figs. 24 and 25 show the result.

The aforementioned semiconductor apparatus is driven at a constant current of 10.5 A (an applied current per element is 0.5 A) while pure water is (conditions of temperature 25°C, and flow rate 0.4 Umin) circulated (Fig. 24). In a passive cooling method as a comparative example, if one element is applied with a current of 0.5 A, it is expected that its output will decrease to about 10% after 100 hours later as shown by a dotted line. However, in the case where it is mounted on the heat sinks that employs active cooling means according to the present invention, even when the LED elements as the heat generating elements are mounted at high density such as an interval between them of about 200 μm, their deterioration after 100 hours later is almost not observed. In this case, although heat density is about 2 Watts/mm^2, the light output is over 3 Watts.

[0183] [EXAMPLE 7-3]

A semiconductor apparatus has twenty-one LED elements that are mounted on a heat sink according to the present invention. The semiconductor apparatus is driven at a constant current of 20 A (an applied current per element is 0.95 A) while pure water (conditions of temperature 25°C, and flow rate 0.4 Umin) is circulated (Fig. 25). In a passive cooling method, if one element is applied with a current of 1 A, it is expected that its output will decrease to about 15% after 10 hours later. However, in the case where it is mounted on the heat sinks that employ active cooling means according to the present invention, even when the LED elements are mounted at high density such as an interval between them of about 200 μm, their deterioration after 10 hours later is almost not observed. In this case, although heat density is about 5 Watts/mm^2, the light output is over 5 Watts.

[0184] [EXAMPLE 7-4]

Simulation is performed on an apparatus (hereinafter, referred to as a "system") that has heat generating elements mounted in a matrix shape on a heat sink assuming that it is placed in a vacuum thermally insulated space and cooling water of 25°C is circulated in the heat sink. Fig. 26 shows the simulation result. In Fig. 26(a), simulation is performed by using a heat sink that has protruding portions with a large diameter located at the center and four corners of the heat generating element (hereinafter, referred to as simply "(a)"). In Fig. 26(b), simulation is performed by using a heat sink that has protruding portions with a small diameter located at the center of the heat generating element (hereinafter, referred to as simply "(b)"). In Fig. 26(c), simulation is performed by using a heat sink that did not have any protruding portions (hereinafter, referred to as simply "(c)").

In the case of (b) rather than (c), and in the case of (a) rather than (b), water pressure distribution of the cooling fluid tends to have contour lines that are perpendicular to the fluid flow. Additionally, the cooling fluid tends to flow uniformly in the whole of flow path. Accordingly, it is found that, in the case of the light emitting device using the heat sink with the protruding portions set as (a), characteristics unevenness due to heat is suppressed.

In the simulation, since cooling water of 25°C is constantly circulated, if the minimum temperature of the system is 25°C or more, heat is stored in the heat sink. In other words, practically, since heat is dissipated toward materials external of the system, it is assumed that the temperature of a package increases.

In the light emitting device that uses the heat sink with protruding portions set as (a), as shown in Figs. 27 and 28, even in the case of small flow rate, since the minimum temperature in the system (the lowest temperature in the heat sink) and the maximum temperature in the system (the highest temperature in the heat sink, i.e., the temperature of the heat generating element itself) are low, heat dissipation external of the system is suppressed. Accordingly, thermal equilibrium can be obtained.

Fig. 20 shows a relationship between thermal resistance calculated based on the maximum temperature of the system and flow rate. The light emitting device that uses the heat sink with protruding portions set as (a) can provide thermal resistance of 0.5°C/Watt or less in the flow rate of 0.3 to 0.7 L/min. This shows that very high density heat can be ejected. According to the light emitting device according to this example, a high-power light emitting device that can be handled with bare hands even in the case where electric power over 100 Watts is continuously applied can be provided.

Industrial Applicability

[0185] A light emitting device can be applied to light emitting devices such as general lighting of phosphor lamp, lighting for signals or automobiles, backlight for LCDs, and display, particularly to white range light and multi-color light emitting devices that use semiconductor light emitting elements.
According to the present invention, since heat dissipation characteristics are excellent, and a phosphor does not deteriorate, the present invention can be applied to a lighting apparatus that has reliability and emits high-power light.
Moreover, the present invention can be applied to a heat sink with a semiconductor light emitting element or a semiconductor photoreceptor element, or a heat generating element such as semiconductor device, formed thereon and to a semiconductor apparatus having this heat sink.

Claims

1. A light emitting device comprising:

   a light emitting element;
   a light conversion member including a phosphor material that is capable of absorbing light emitted from said light emitting element at least partially and emitting light in different wavelength; and
   a heat dissipation member that is located in a side where said light conversion member is provided as viewed from said light emitting element.

2. The light emitting device according to claim 1, wherein said heat dissipation member has a flow path of a refrigerant.

3. The light emitting device according to claim 2, wherein said heat dissipation member includes at least one pair of an inlet for admission of said refrigerant and an outlet for ejection of the refrigerant that is circulated through said flow path.

4. The light emitting device according to claim 3, wherein said heat dissipation member is formed of a material that passes at least light from said light emitting element, or a material that passes light from both said light emitting element and said light conversion member.

5. The light emitting device according to claim 1, wherein said heat dissipation member is formed of two plate-shaped members that form the flow path for flowing cooling fluid between them, and a plurality of said light emitting elements are mounted to be two-dimensionally arranged on a main surface of said heat dissipation member, wherein a plurality of protruding portions are formed in the surface of said plate-shaped member inside said flow path, and at least some of said plurality of protrudin portions are formed such that their centers are located between said light emitting elements and a substantially central art of said light emitting element.

6. A light emitting device comprising a light emitting element, a light conversion member including a phosphor material that is capable of absorbing light emitted from the light emitting element at least partially and emitting light in different wavelength, and a heat dissipation member, wherein
   said heat dissipation member having a flow path of a refrigerant includes a first heat dissipation member that has a first flow path in a side where said light emitting element is mounted, and a second heat dissipation member that has a second flow path in a side where light from said light emitting element is incident, the second heat dissipation member including said light conversion member.

7. The light emitting device according to claim 6, wherein said flow path includes a third flow path that connects said first flow path to said second flow path.

8. The light emitting device according to claim 7, wherein each or one of said first and second heat dissipation members includes a pair of an inlet for admission of said refrigerant and an outlet for ejection of the refrigerant that is circulated through said flow path.

9. The light emitting device according to claim 8, wherein said first heat dissipation member, an insulating member, a supporting substrate, and said second heat dissipation member are laminated.

10. The light emitting device according to claim 9, wherein said heat dissipation member has said inlet or outlet in at

least one of main surface sides, and said insulating member and said supporting substrate have through holes that form parts of said third flow path.

11. The light emitting device according to claim 10, wherein a conductive member that contains at least one element selected the group consisting of Au, Ag, and Al is coated on at least one of main surfaces of said insulating member.

12. The light emitting device according to claim 11, wherein one electrode of said light emitting element is electrically connected to the conductive member that is coated on coated on the at least one of main surfaces of said insulatin member via a conductive wire, another electrode is electrically connected to said first heat dissipation member.

13. The light emitting device according to claim 12, wherein said second heat dissipation member is formed of a material that passes at least light from said light emitting element, or a material that passes light from both said light emitting element and said light conversion member.

14. The light emitting device according to claim 6, wherein each or one of said first and second heat dissipation members is formed of two plate-shaped members that form the flow path for flowing cooling fluid between them, and a plurality of said light emitting elements are mounted to be two-dimensionally arranged on a main surface of said first heat dissipation member, wherein a plurality of protruding portions are formed in the surface of said plate-shaped member inside said flow path, and at least some of said plurality of protruding portions are formed such that their centers are located between said light emitting elements and a substantially central part of said light emitting element.

15. A light emitting device comprising a heat dissipation member that is formed of two plate-shaped members that form a flow path for flowing cooling fluid between them, and a plurality of light emitting elements that are mounted to be two-dimensionally arranged on a main surface of the heat dissipation member, wherein
a plurality of protruding portions are formed in the surface of said plate-shaped member inside said flow path, and at least some of said plurality of protruding portions are formed such that their centers are located between said light emitting elements and a substantially central part of said light emitting element.

16. The light emitting device according to claim 15, wherein said plurality of protruding portions are arranged apart from each other in the bended manner such that line segments that successively connect the protruding portions closest to each other repeatedly change their direction from a inlet part to a outlet part of said flow path.

17. The light emitting device according to claim 16, wherein at least some of said plurality of protruding portions are formed such that their centers are located between said light emitting elements.

18. The light emitting device according to claim 17, wherein said plurality of protruding portions are located at a substantially central part of and in the peripheries of the corners of the light emitting element.

19. The light emitting device according to claim 18, wherein a metal material containing Au coats an attachment surface of said plate-shaped members.

FIG.1

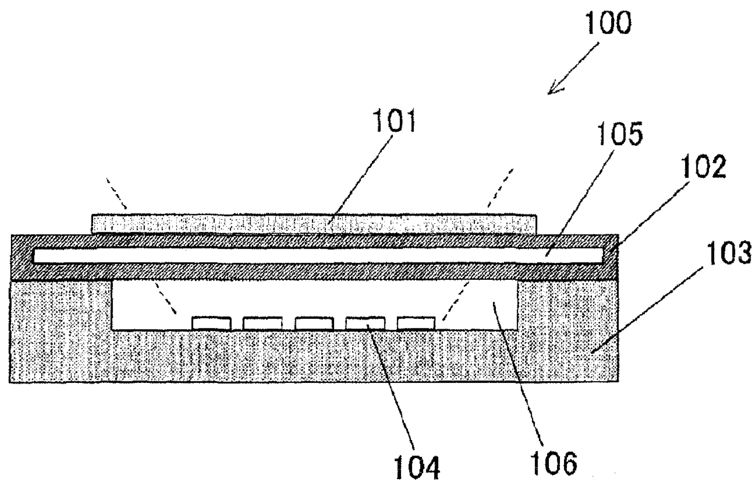


FIG.2

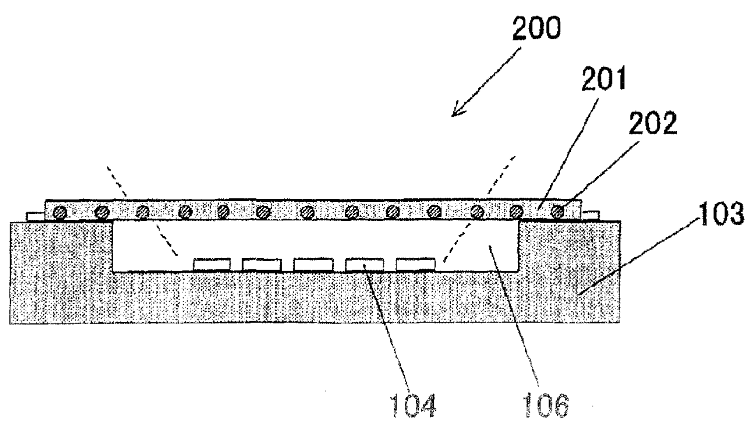


FIG.3

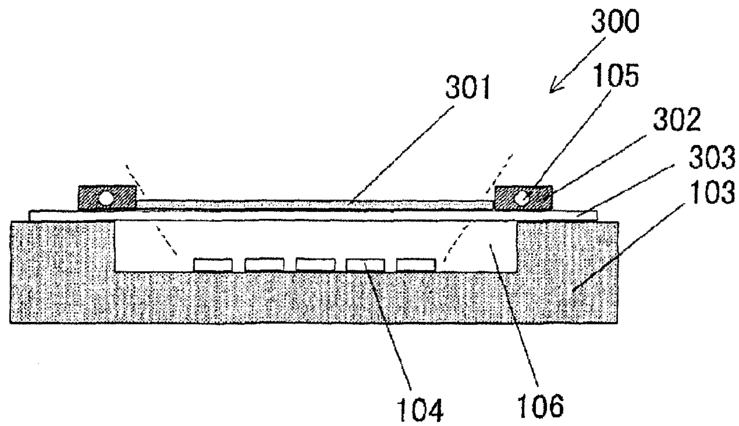


FIG.4

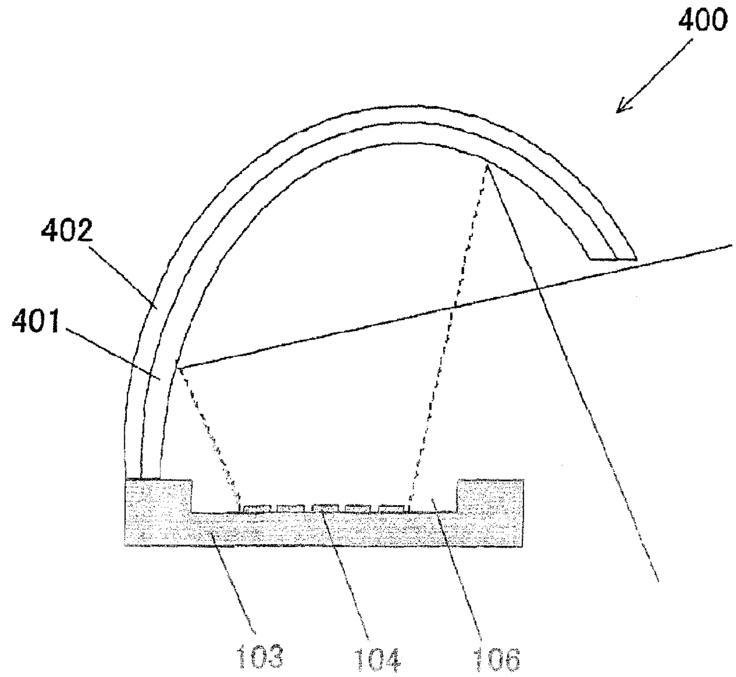


FIG.5

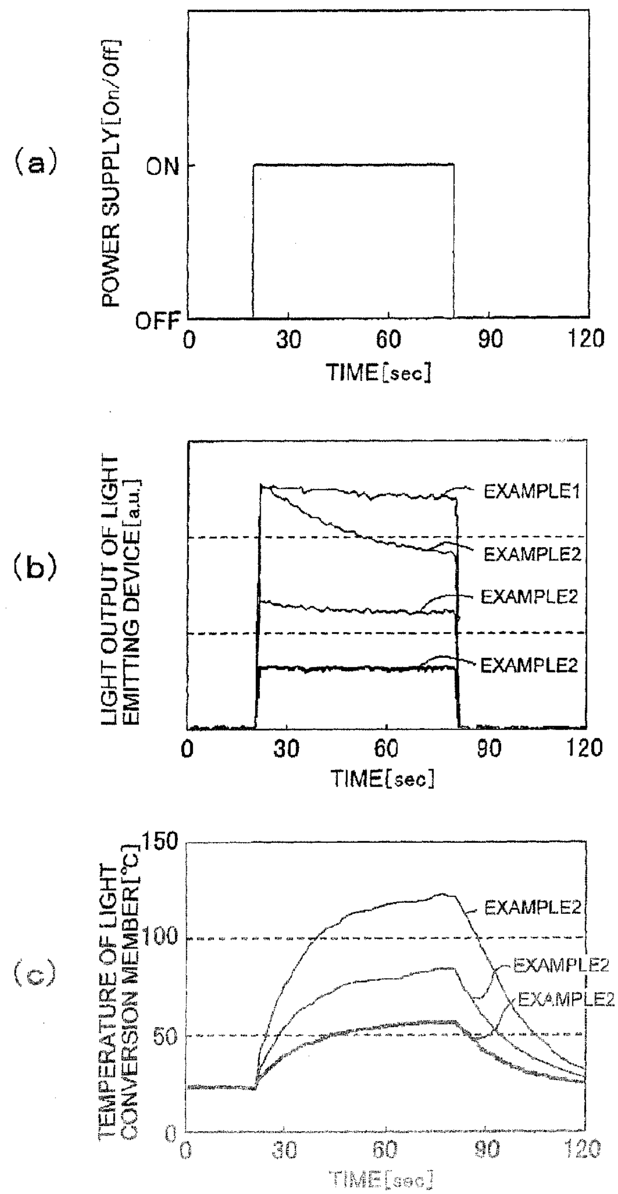

(a)
POWER SUPPLY[On/Off]
ON
OFF
0
30
60
90
120
TIME[sec]
(b)
LIGHT OUTPUT OF LIGHT EMITTING DEVICE[a.u.]
EXAMPLE1
EXAMPLE2
EXAMPLE2
EXAMPLE2
0
30
60
90
120
TIME[sec]
(c)
TEMPERATURE OF LIGHT CONVERSION MEMBER[°C]
150
100
50
0
EXAMPLE2
EXAMPLE2
EXAMPLE2
0
30
60
90
120
TIME[sec]

FIG.6

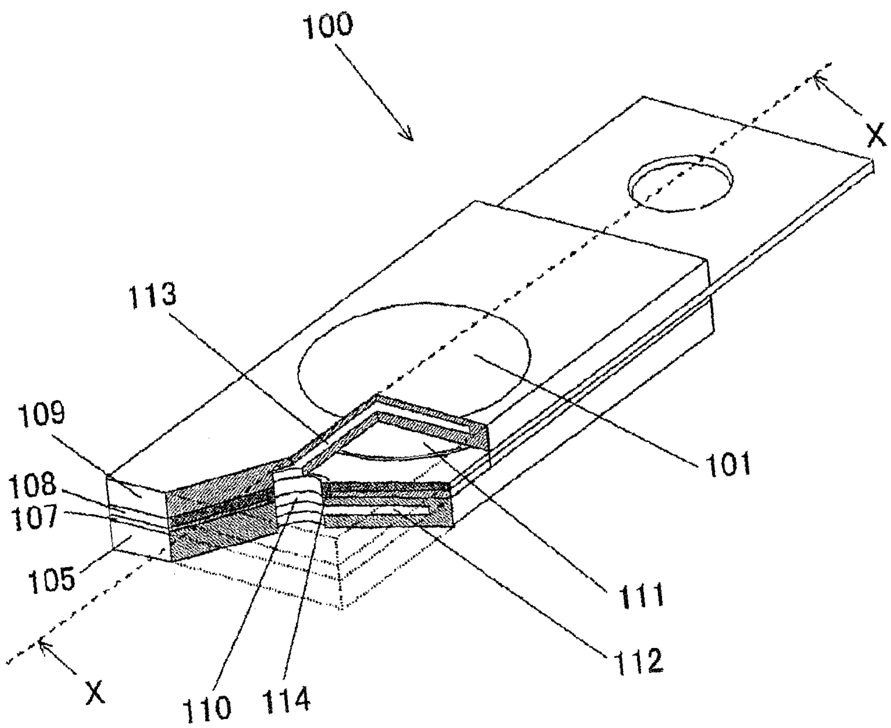


FIG.7

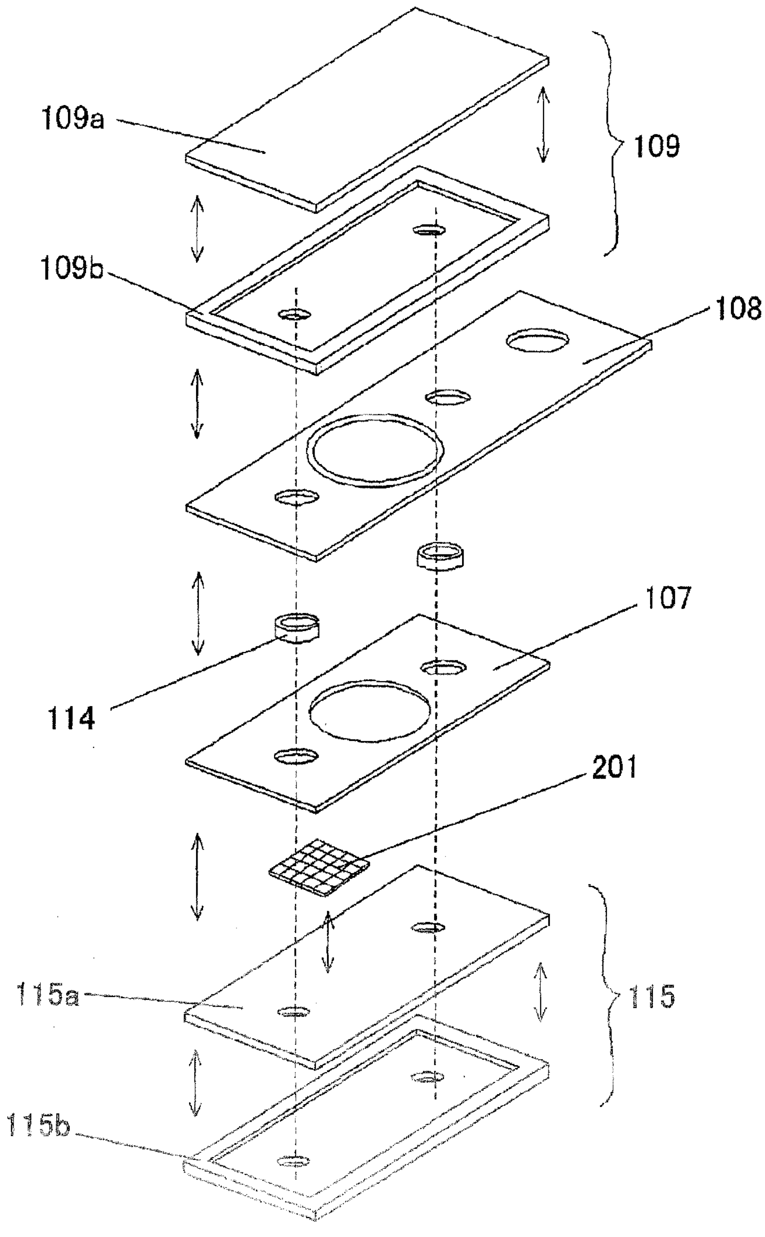


FIG.8

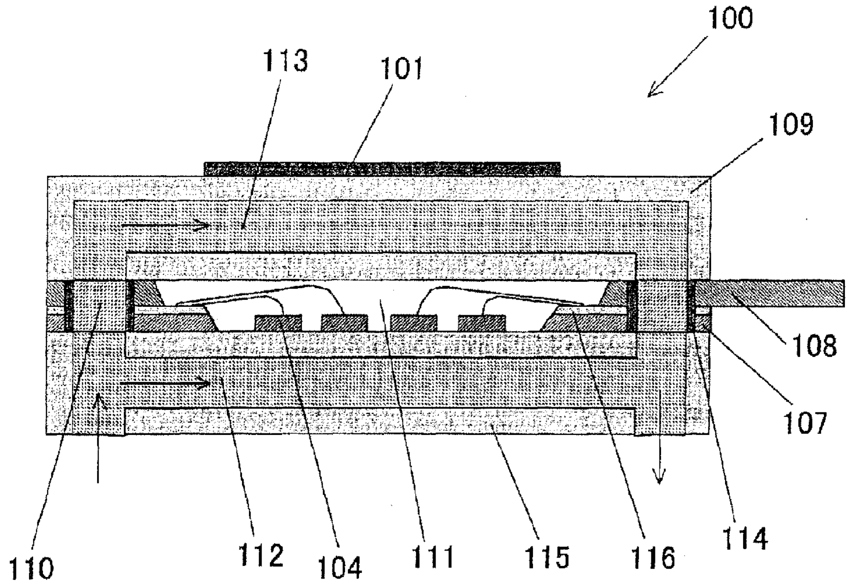

100
113
101
109
108
107
110
112
104
111
115
116
114

FIG.9

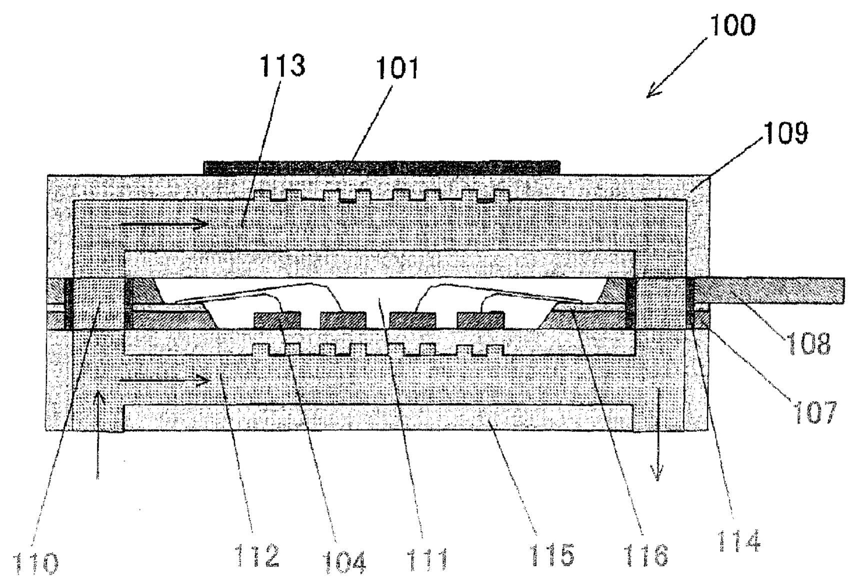

100
113
101
109
108
107
110
112
104
111
115
116
114

FIG.10

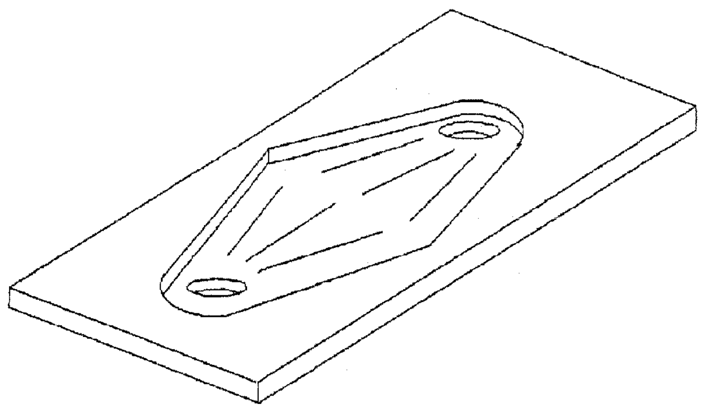


FIG.11

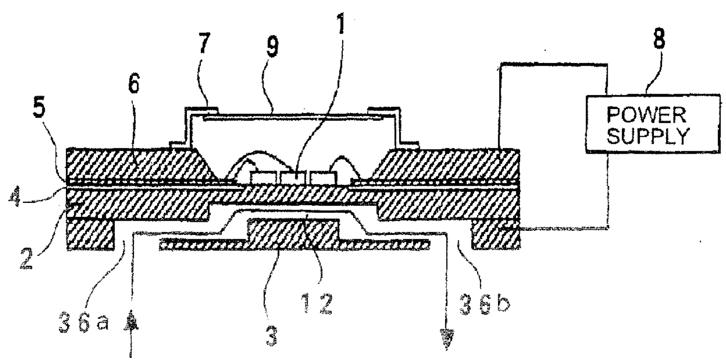


FIG.12

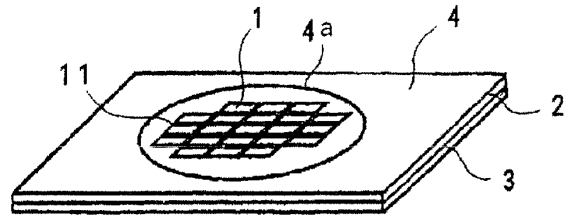


FIG.13

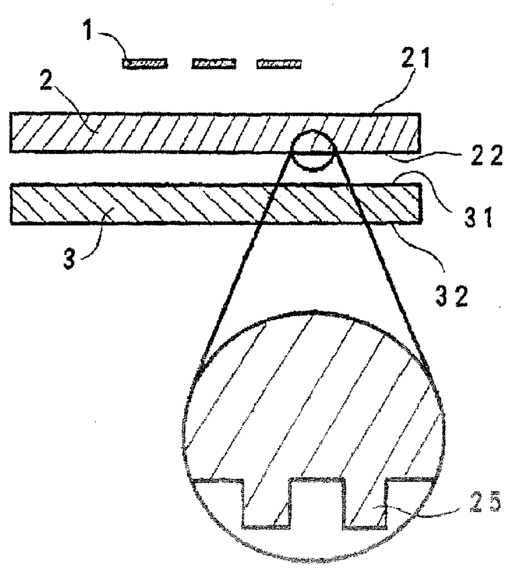


FIG.14

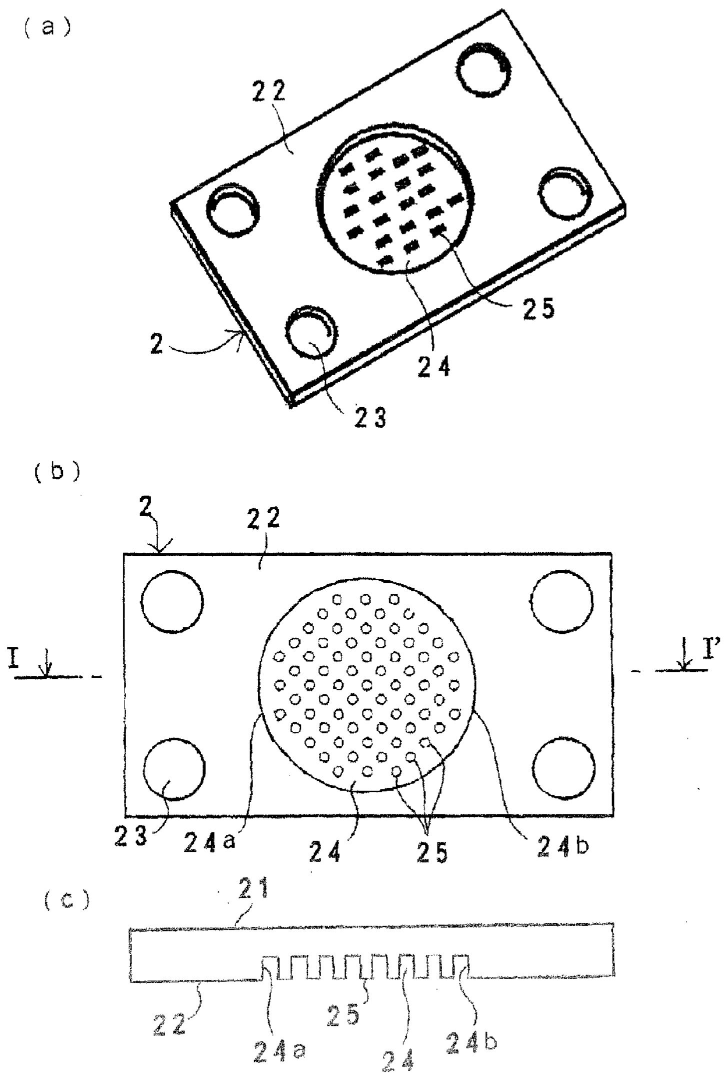


FIG.15

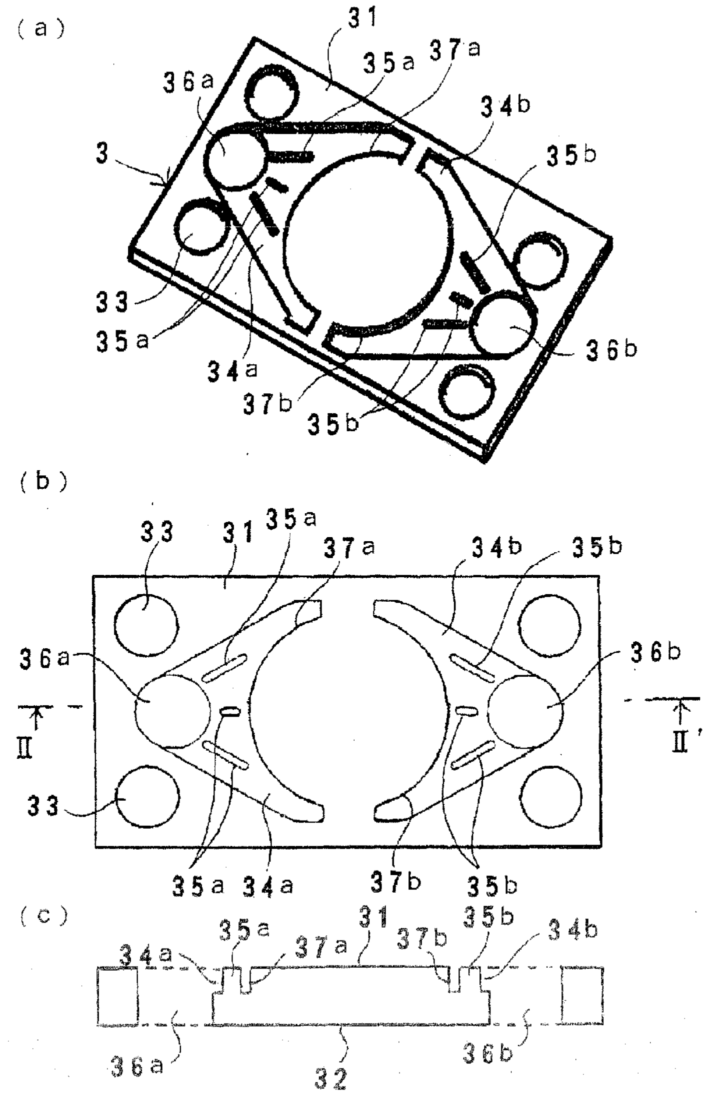
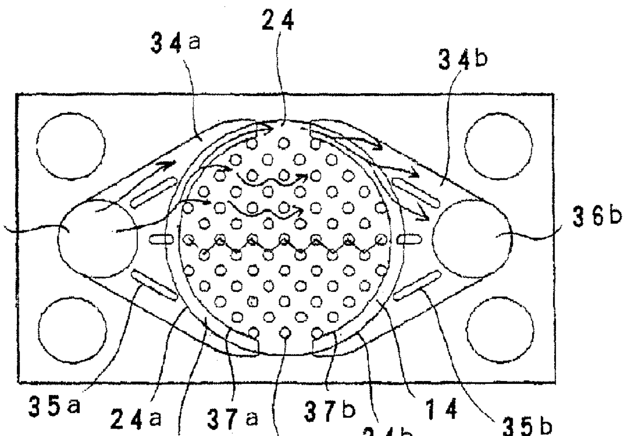

(a)
31
35a
37a
36a
34b
3
35b
33
35a
36b
34a
37b
35b
(b)
33
31
35a
37a
34b
35b
36a
36b
II
II'
33
35a
34a
37b
35b
(c)
35a
31
35b
34b
34a
37a
37b
36a
32
36b

FIG.16

(a)


24
34a
34b
36a
36b
35a
24a
37a
37b
14
35b
13
25
24b

(b)

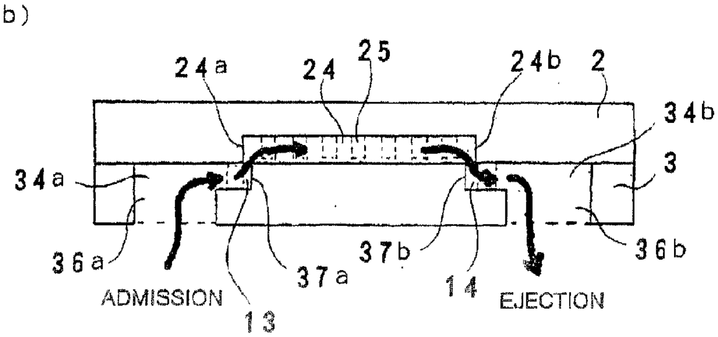

24a
24
25
24b
2
34b
3
34a
36a
37a
37b
36b
ADMISSION
13
14
EJECTION

FIG.17

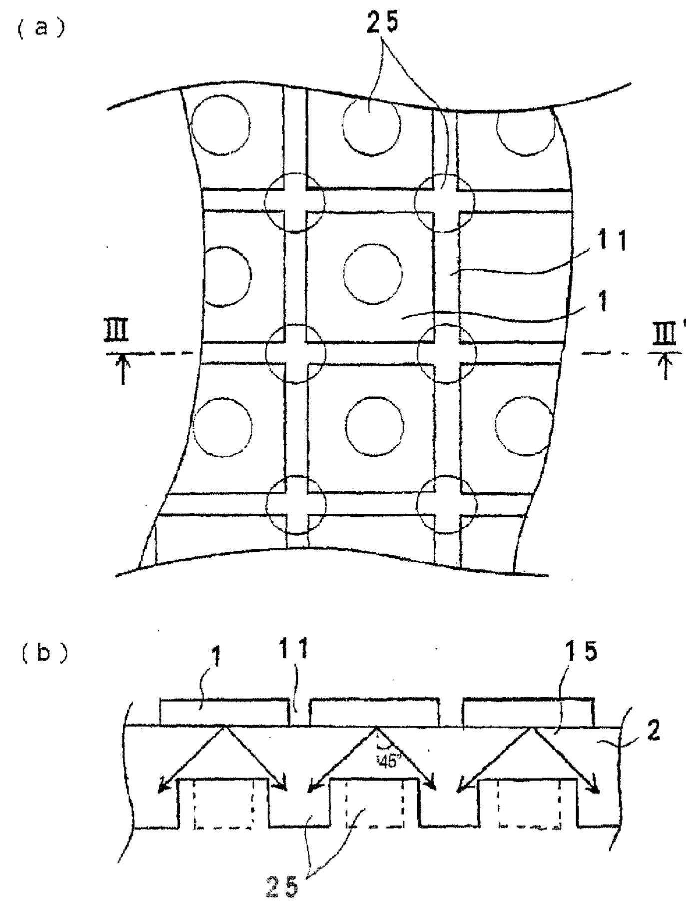


FIG.18

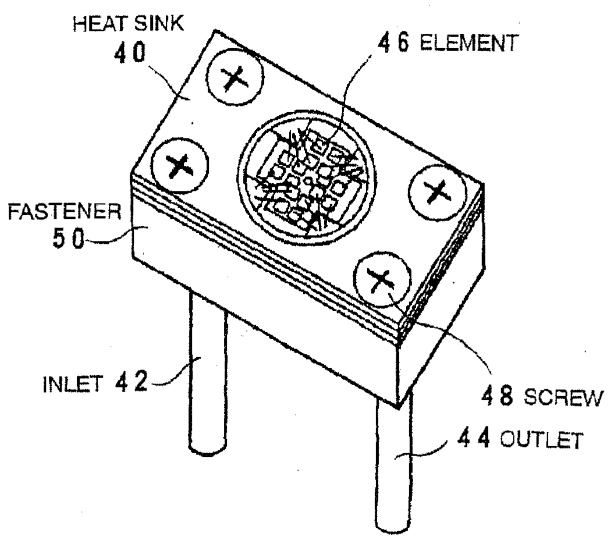

HEAT SINK
40
46 ELEMENT
FASTENER
50
INLET 42
48 SCREW
44 OUTLET

FIG.19

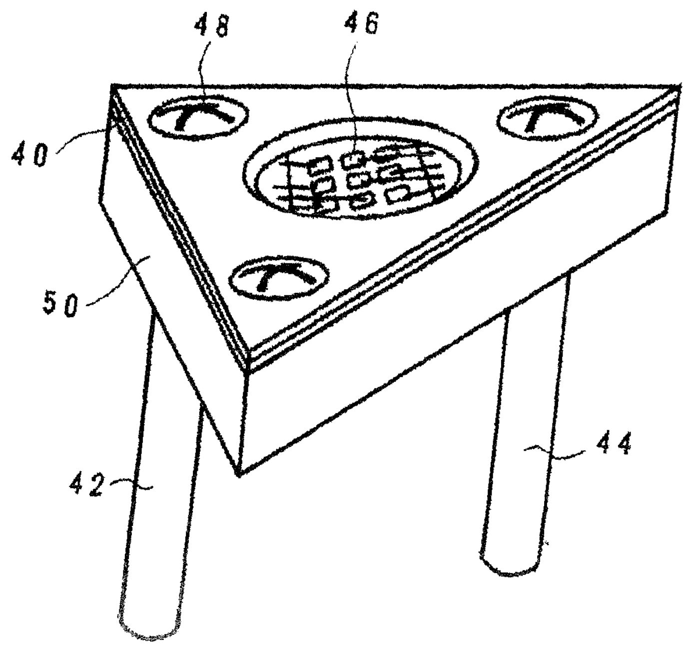


FIG.20

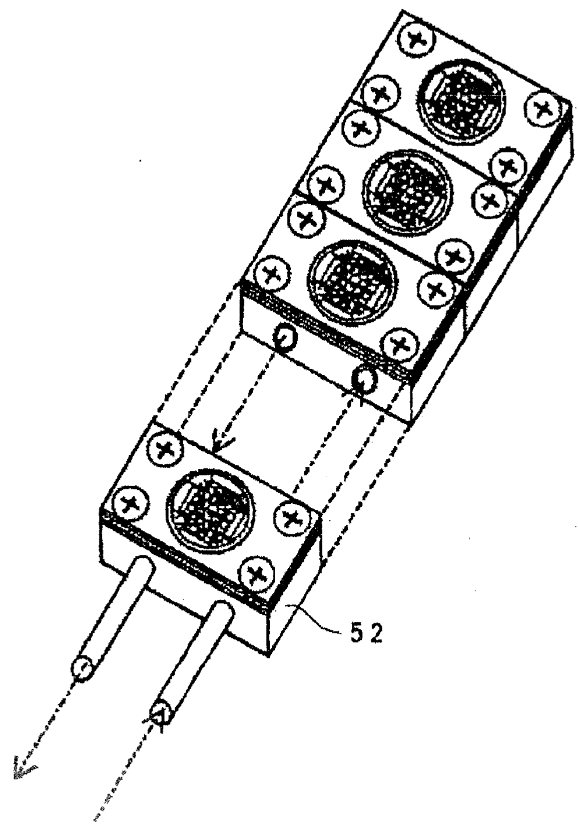


FIG.21

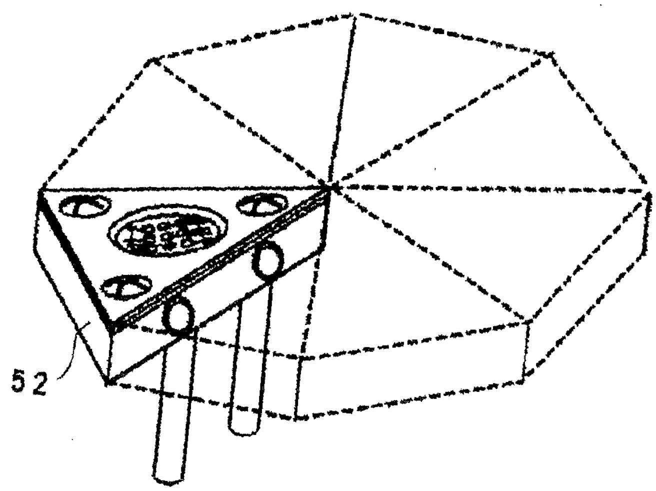


FIG.22

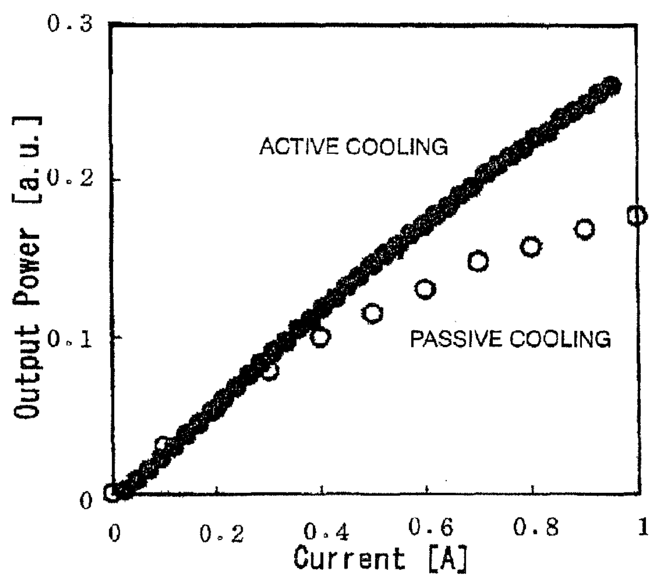

0.3
0.2
0.1
0
Output Power [a.u.]
ACTIVE COOLING
PASSIVE COOLING
0
0.2
0.4
0.6
0.8
1
Current [A]

FIG.23

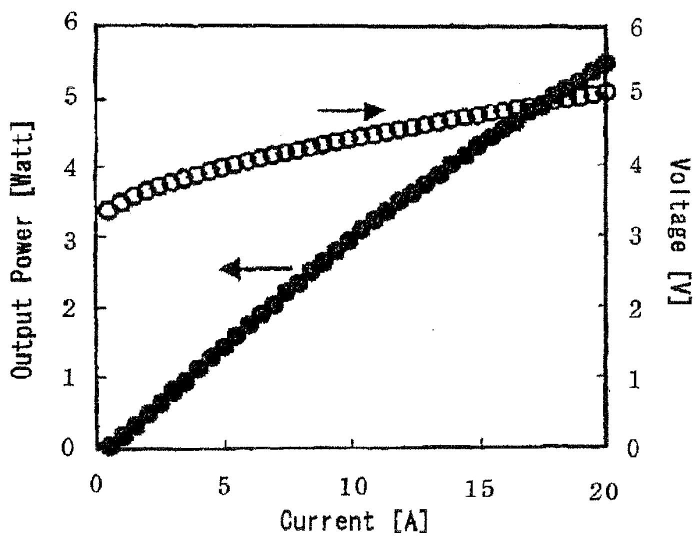

6
5
4
3
2
1
0
Output Power [Watt]
6
5
4
3
2
1
0
Voltage [V]
0
5
10
15
20
Current [A]

FIG.24

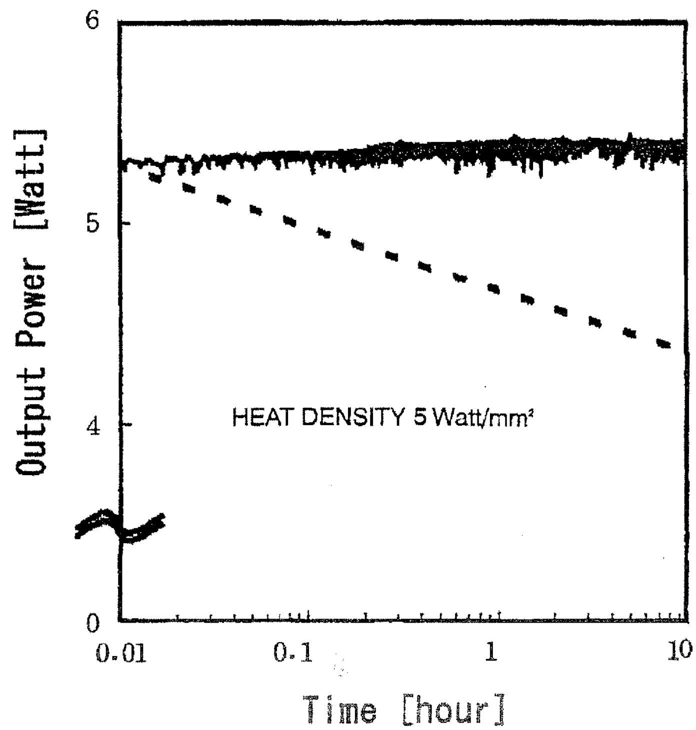

6
5
4
0
Output Power [Watt]
HEAT DENSITY 5 Watt/mm²
0.01
0.1
1
10
Time [hour]

FIG.25

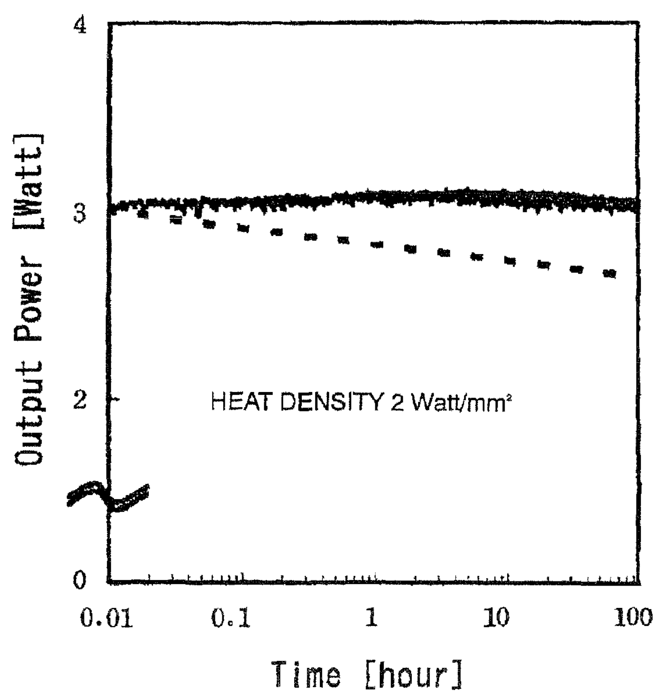
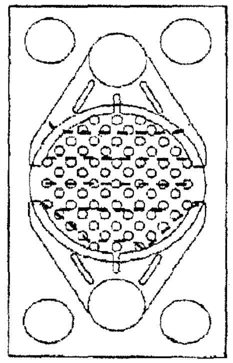
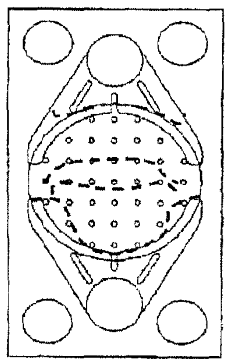

4
3
2
0
Output Power [Watt]
HEAT DENSITY 2 Watt/mm²
0.01
0.1
1
10
100
Time [hour]

FIG.26

(a)



(b)



(c)

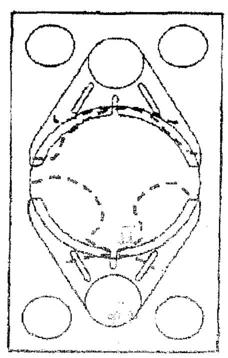


FIG.27

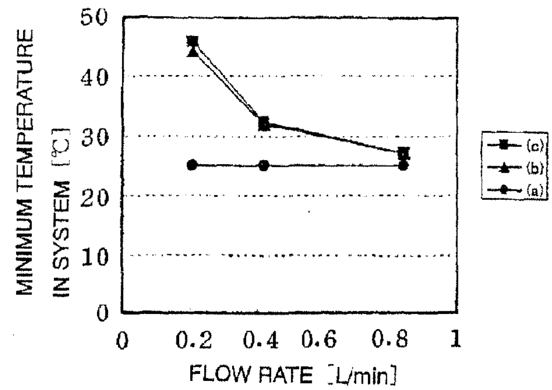


FIG.28

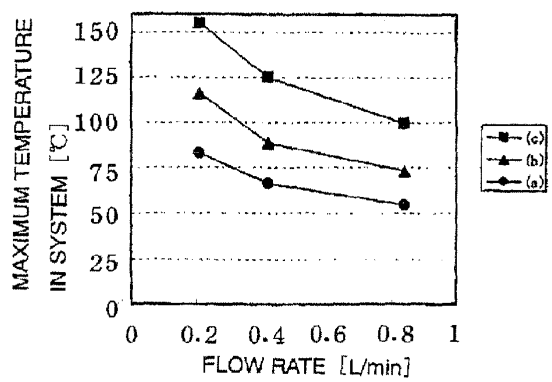
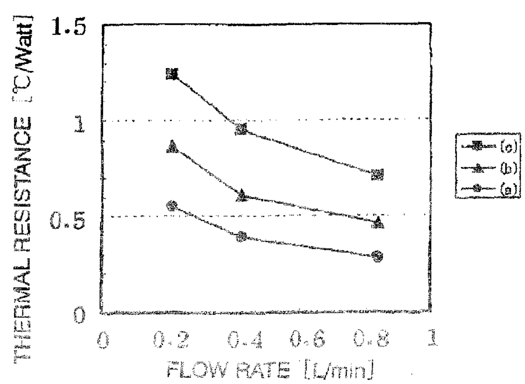


FIG.29



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/015259

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl7 H01L33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl7 H01L33/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2005
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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 47-27495 A (NEC Corp.), 28 October, 1972 (28.10.72), Page 2, lower left column to page 3, upper right column; Fig. 3 (Family: none)	1
Y	JP 11-163412 A (Matsushita Electric Works, Ltd.), 18 June, 1999 (18.06.99), Full text; all drawings & EP 0921568 A2	15-19

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/015259

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2002-353515 A (Samsung Electro-Mechanics Co., Ltd.), 06 December, 2002 (06.12.02), Full text; all drawings & US 2002/0175621 A1	15-19
Y	WO 2003/0001612 A1 (Nichia Chemical Industries, Ltd.), 03 January, 2003 (03.01.03), Full text; all drawings (Family: none)	15-19
Y	JP 2003-92009 A (Matsushita Electric Industrial Co., Ltd.), 28 March, 2003 (28.03.03), Full text; all drawings & US 2003/052584 A1	15-19
Y	JP 9-307040 A (Hitachi, Ltd.), 28 November, 1997 (28.11.97), Full text; all drawings (Family: none)	15-19
Y	JP 2002-315358 A (Hitachi, Ltd.), 25 October, 2002 (25.10.02), Full text; all drawings (Family: none)	15-19
Y	JP 2000-92858 A (Hitachi, Ltd.), 31 March, 2000 (31.03.00), Full text; all drawings (Family: none)	15-19
A	JP 2002-353516 A (Nichia Chemical Industries, Ltd.), 06 December, 2002 (06.12.02), Full text; all drawings (Family: none)	1-19
A	JP 2001-36148 A (Matsushita Electric Works, Ltd.), 09 February, 2001 (09.02.01), Full text; all drawings (Family: none)	1-19

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/015259

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The inventions of claims 1-14 relate to heat dissipation of a light-converting member.

The inventions of claims 15-19 relate to heat dissipation of a light-emitting device.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)

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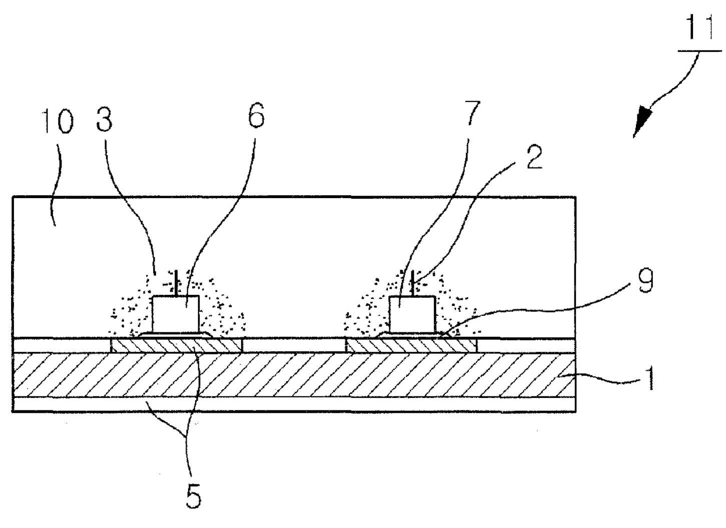
[Continued on next page]

(54) Title: LIGHT EMITTING DEVICE



(57) Abstract: Disclosed herein is a light emitting device including one or more light emitting diodes to primarily emit light having different wavelengths in the wavelength range of ultraviolet rays and/ or blue light, and a wavelength-conversion means to convert the primary light into secondary light in the visible light wavelength range. The light emitting device of the current invention has a high color temperature of 2000 to 8000 K or 10000 K and a high color rendering index of 90 or more, thus easily realizing desired emission on the color coordinate system. Therefore, the lighting emitting device is applicable to mobile phones, notebook computers, and keypads or backlight units for various electronic products, and, in particular, automobiles and exterior and interior lighting fixtures.

WO 2005/109532 A1

SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Description

LIGHT EMITTING DEVICE

Technical Field

[1] The present invention relates, in general, to a light emitting device (LED), and more particularly, to an LED comprising at least one light emitting source and a wavelength-conversion means to convert a wavelength of light generated by the light emitting source into a wavelength exhibiting a predetermined color of light.

Background Art

[2] Generally, an LED is advantageous because it has low power consumption and a long lifetime, and also, it can be mounted in limited spaces and is highly resistant to vibration. Recently, single color LEDs, for example, red, blue or green LEDs, and as well, white LEDs have been disclosed. Of these LEDs, the white LED is expected to be increasingly used as it is applied to automotive products and lighting fixtures.

[3] In the LED techniques, white color is mainly realized by the two following methods. In the first method, red, blue and green light emitting diodes are disposed to be adjacent to one another, and colors of light emitted by the light emitting diodes combine to realize white light. However, since the light emitting diodes have different thermal or temporal properties, the hue changes depending on usage conditions. In particular, non-uniform color, such as color irregularity, is exhibited.

[4] As a second method, a phosphor is included in the light emitting diode, and thus, primary light emitted by the light emitting diode is partially combined with secondary light converted into a predetermined wavelength by the phosphor to realize a white color. This method, for example, adopts a blue light emitting diode having a peak emission wavelength between 450 and 490 nm and a YAG phosphor to absorb light emitted by the blue light emitting diode and convert it into almost yellow fluorescent rays, and is disclosed in WO 98/05078 and WO 98/12757.

[5] However, the above second method is disadvantageous because it cannot provide high white emission properties due to the YAG phosphor. That is, the YAG phosphor exhibits high emission efficiency only in the wavelength range lower than a peak emission wavelength of 560 nm. Thus, when such a phosphor is mixed with a blue light emitting diode having a wavelength between 450 and 490 nm, a low color temperature of 6000 to 8000 K and a low color rendering index of 60 to 75 are manifested, thus exhibiting a cool blue-white color.

[6] Therefore, limitations are imposed on applications of the conventional white LEDs to various products. In particular, such an LED cannot be used for lighting fixtures.

Disclosure of Invention

Technical Problem

[7] Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and an object of the present invention is to provide an LED having a wavelength-conversion means, which is advantageous in that because it has a high color temperature of about 2000 to 8000 K or 10000 K and a high color rendering index of 90 or more, it can be applied to electronic products, such as home appliances, audio systems and communication products, and as well, various exterior and interior displays, in particular, automobiles and lighting fixtures.

Technical Solution

[8] In order to achieve the above object, the present invention provides an LED, which comprises one or more light emitting diodes to primarily emit light having different wavelengths in a wavelength range of ultraviolet rays and/or blue light; and a wavelength-conversion means to convert the primary light into secondary light in a visible light wavelength range.

[9] In a preferred embodiment, the one or more light emitting diodes include a first light emitting diode having a peak emission wavelength between 360 and 420 nm; a second light emitting diode having a peak emission wavelength between 400 and 450 nm; and a third light emitting diode having a peak emission wavelength between 430 and 500 nm.

[10] In another preferred embodiment, the one or more light emitting diodes include a first light emitting diode having a peak emission wavelength between 390 and 450 nm; and a second light emitting diode having a peak emission wavelength between 440 and 500 nm, and the wavelength-conversion means to convert primary light into secondary light in the visible light wavelength range includes a phosphor.

[11] Further, the light emitting diodes to emit primary light and the wavelength-conversion means are mounted in a single package. As such, the single package is formed into a chip package, which comprises a substrate, one or more light emitting diodes mounted on the substrate, and a wavelength-conversion means placed around the light emitting diodes, or is formed into a top package, which comprises a substrate having a reflector formed thereon, one or more light emitting diodes mounted on the substrate, and a wavelength-conversion means placed around the light emitting diodes.

[12] Moreover, when the substrate of the chip package or top package is formed of metal, heat generated by the one or more light emitting diodes can be effectively emitted. In addition, a radiation sheet is also mounted on the substrate formed of metal, thus further increasing heat emission efficiency.

[13] On the substrate of the chip package or top package, a molded part to enclose the light emitting diodes and the wavelength-conversion means is preferably further

formed. In this case, the wavelength-conversion means is uniformly distributed in the molded part.

[14] Further, the single package is formed into a lamp package, which comprises a pair of lead electrodes, one or more light emitting diodes mounted on one of the pair of lead electrodes, a wavelength-conversion means placed around the light emitting diodes, and a molded part to enclose the light emitting diodes and the wavelength-conversion means.

[15] Furthermore, the single package is formed into a high output package, which comprises one or more light emitting diodes, a wavelength-conversion means placed around the light emitting diodes, and a heat sink to emit heat generated by the one or more light emitting diodes. As such, a radiation sheet to emit heat from the heat sink is additionally included to further increase heat emission efficiency.

[16] Also, the light emitting diodes each include a substrate formed of silicon carbide or sapphire and a nitride epitaxial layer formed on the substrate.

[17] The wavelength-conversion means includes one or more phosphors having different properties, and is placed on at least one of a side surface, an upper surface and a lower surface of the light emitting diode, or is used in a mixture with an adhesive or a molding material.

[18] In a preferred embodiment, the wavelength-conversion means includes any one selected from among a first phosphor having a peak emission wavelength between 440 and 500 nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, a third phosphor having a peak emission wavelength between 580 and 700 nm, and mixtures thereof.

[19] In another preferred embodiment, the wavelength-conversion means includes any one selected from among a first phosphor having a peak emission wavelength between 440 and 500 nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, a third phosphor having a peak emission wavelength between 580 and 700 nm, and mixtures thereof.

[20] Further, each phosphor comprises one or more phosphor components having different properties in the corresponding wavelength range.

Description of Drawings

[21] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[22] FIG. 1 is a longitudinal sectional view schematically showing an LED according to a first embodiment of the present invention, in which the LED is formed into a chip package comprising two light emitting diodes and a wavelength-conversion means;

[23] FIG. 2 is a graph showing the emission spectrum of the LED according to the first

embodiment of the present invention, in which the LED is formed into the chip package comprising two blue light emitting diodes having different peak emission wavelengths and a wavelength-conversion means including a mixture of phosphors having peak emission wavelengths corresponding to green, yellow and orange light;

[24] FIG. 3 is a longitudinal sectional view schematically showing an LED according to a second embodiment of the present invention, in which the LED is formed into a chip package comprising three light emitting diodes and a wavelength-conversion means;

[25] FIG. 4 is a graph showing the emission spectrum of the LED according to the second embodiment of the present invention, in which the LED is formed into the chip package comprising three blue light emitting diodes having different peak emission wavelengths and a wavelength-conversion means including a mixture of phosphors having peak emission wavelengths corresponding to green, orange and red light;

[26] FIG. 5 is a graph showing the emission spectrum of the chip package comprising three blue light emitting diodes having different peak emission wavelengths and a wavelength-conversion means including a mixture of phosphors having peak emission wavelengths corresponding to green and orange light;

[27] FIG. 6 is a longitudinal sectional view schematically showing a top package according to a third embodiment of the present invention;

[28] FIG. 7 is a perspective view showing a side package according to a fourth embodiment of the present invention;

[29] FIG. 8 is a longitudinal sectional view schematically showing a lamp package according to a fifth embodiment of the present invention;

[30] FIG. 9 is a longitudinal sectional view schematically showing a high output package according to a sixth embodiment of the present invention; and

[31] FIG. 10 is a longitudinal sectional view schematically showing a high output package according to a seventh embodiment of the present invention.

Best Mode

[32] Hereinafter, a detailed description will be given of preferred embodiments of the present invention, with reference to the appended drawings.

[33] FIG. 1 is a longitudinal sectional view schematically showing an LED according to a first embodiment of the present invention, in which a chip package including two light emitting diodes and a wavelength-conversion means is shown. As shown in the drawing, a substrate 1 has electrode patterns 5 formed on both surfaces thereof, and two light emitting diodes 6 and 7 to primarily generate blue light having different wavelengths are mounted on either electrode pattern 5. The light emitting diodes 6 and 7 are mounted on the electrode pattern 5 using a conductive adhesive 9, and electrodes of the light emitting diodes 6 and 7 are connected to another electrode pattern (not shown) by means of a conductive wire 2.

[34] A wavelength-conversion means 3 is placed on upper surfaces and side surfaces of the two light emitting diodes 6 and 7. The wavelength-conversion means 3 functions to convert blue light generated by the light emitting diodes 6 and 7 into secondary light in the visible light wavelength range. The wavelength-conversion means 3 mixed with a resin, for example, an epoxy resin or a silicone resin may be dotted on the light emitting diodes 6 and 7. In addition, the wavelength-conversion means 3 mixed with the conductive adhesive 9 may be placed on the lower surfaces of the light emitting diodes 6 and 7.

[35] An upper portion of the substrate 1 having the two light emitting diodes 6 and 7 mounted thereon is molded using the resin to form a molded part 10. In the LED 11 according to the first embodiment of the present invention, the wavelength-conversion means 3 is uniformly dotted on the upper surfaces and side surfaces of the light emitting diodes 6 and 7 at a predetermined thickness. Alternatively, the wavelength-conversion means 3 may be uniformly distributed throughout the molded part 10, which is disclosed in U.S. Patent No. 6,482,664 filed by the present inventors.

[36] Of the two blue light emitting diodes 6 and 7, a first light emitting diode 6 has a peak emission wavelength between 390 and 450 nm, and a second light emitting diode 7 has a peak emission wavelength between 440 and 500 nm. Each of the first and second light emitting diodes 6 and 7 includes a substrate made of silicon carbide or sapphire and a nitride epitaxial layer formed on the substrate.

[37] The wavelength-conversion means 3 includes a single phosphor or a mixture of different phosphors. That is, the wavelength-conversion means 3 includes at least one phosphor selected from among a first phosphor having a peak emission wavelength between 440 and 500 nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, and a third phosphor having a peak emission wavelength between 580 and 700 nm. In addition, each phosphor may consist of one or more phosphor components having different peak emission wavelengths in the corresponding wavelength range.

[38] The phosphor of the wavelength-conversion means 3 is composed of orthosilicates represented by a general formula of $(Ba,Sr,Ca)_xSiO_4$:Eu and/or Mn. As such, the mixing ratio of Ba, Sr and Ca, the mixing ratio of $(Ba,Sr,Ca)_xSiO_4$:Eu and $(Ba,Sr,Ca)_xSiO_4$:Mn, and the mixing ratio of Ba, Sr, Ca, Mn and Eu are appropriately controlled to obtain the first phosphor having a peak emission wavelength between 440 and 500 nm, the second phosphor having a peak emission wavelength between 500 and 590 nm, and the third phosphor having a peak emission wavelength between 580 and 700 nm. In this way, the phosphors are mixed with each other at an appropriate ratio to constitute the wavelength-conversion means 3.

[39] In the chip package 11 as the LED according to the first embodiment, the first light

emitting diode 6 and the second light emitting diode 7 are supplied with external power by means of the electrode pattern 5. Thereby, blue light having a peak emission wavelength between 390 and 450 nm and blue light having a peak emission wavelength between 440 and 500 nm are primarily generated by the first light emitting diode 6 and the second light emitting diode 7, respectively. Subsequently, the primary blue light thus generated excites the phosphors, which then secondarily produce light having peak emission wavelengths between 440 and 500 nm, between 500 and 590 nm, and between 580 and 700 nm. Hence, the primary blue light generated by the first and second light emitting diodes 6 and 7 is combined with the secondary light converted into predetermined wavelengths by the phosphors to realize the color of the corresponding visible light wavelength range.

[40] Further, the desired color is realized by appropriately controlling the mixing ratios of the phosphors. For example, in the case where the first phosphor having a peak emission wavelength between 440 and 500 nm and the second phosphor having a peak emission wavelength between 500 and 590 nm are used, the secondary light ranging from 580 to 700 nm is not generated. Hence, the primary blue light emitted by the first light emitting diode 6 and the second light emitting diode 7 is combined with the secondary light converted into predetermined wavelengths by the phosphors, thus realizing a predetermined color of the corresponding visible light wavelength range. In addition to the mixing ratios of the phosphors, the light emitting diodes having desired peak emission wavelengths in the corresponding wavelength ranges may be appropriately selected to achieve the desired emission on the color coordinate system.

[41] Therefore, when the two blue light emitting diodes 6 and 7 having different wavelengths are used and the phosphors having different peak emission wavelengths (blue, green or orange) are also mixed, the LED having the emission spectrum shown in FIG. 2 is manufactured. Such an LED has a color temperature of 3,500 to 7,500 K and a color rendering index of about 80-93.

[42] In the present embodiment, the light emitting diodes are appropriately selected and the mixing ratios of the phosphors are suitably controlled, so that the desired emission on the color coordinate system can be easily achieved. The LED according to the first embodiment is easily applicable to electronic products, such as home appliances, audio systems and communication products, and as well, various exterior and interior displays, in particular, automobiles and lighting fixtures.

[43] FIG. 3 is a longitudinal sectional view schematically showing an LED according to a second embodiment of the present invention, in which a chip package including three light emitting diodes and a wavelength-conversion means is seen. The LED according to the second embodiment of the present invention has the same structure as in the first embodiment of FIGS. 1 and 2, with the exception that one light emitting diode is

further included. However, light emitting diodes 16, 17 and 18 and phosphors constituting a wavelength-conversion means 13 of the LED according to the second embodiment have properties different from the first embodiment.

[44] A first light emitting diode 16 has a peak emission wavelength between 360 and 420 nm, and a second light emitting diode 17 has a peak emission wavelength between 400 and 450 nm. In addition, a third light emitting diode 18 has a peak emission wavelength between 430 and 500 nm. Further, the wavelength-conversion means 13 includes a first phosphor having a peak emission wavelength between 440 and 500 nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, and a third phosphor having a peak emission wavelength between 580 and 700 nm, which are mixed with each other at an appropriate ratio.

[45] When the first, second and third light emitting diodes 16, 17 and 18 are supplied with external power by means of the electrode pattern 5, the first, second and third light emitting diodes 16, 17 and 18 primarily produce light at the corresponding peak emission wavelengths. Subsequently, the primary light is partially converted into secondary light having peak emission wavelengths between 420 and 490 nm, between 480 and 580 nm, and between 570 and 690 nm, by the excited phosphors. In this case, the primary light emitted by the light emitting diodes 16, 17 and 18 is combined with the secondary light converted into predetermined wavelengths by the phosphors to obtain light in the visible light wavelength range.

[46] As such, each phosphor may consist of one or more phosphor components having different peak emission wavelengths in the corresponding wavelength range. In addition, the mixing ratios of the phosphors are appropriately controlled, and thus, the emission wavelength may be shifted into a desired emission wavelength on the color coordinate system.

[47] In the LED 20 according to the second embodiment, the same objects and effects as in the first embodiment of FIGS. 1 and 2 are achieved. FIG. 4 shows the emission spectrum of the chip package having three light emitting diodes 16, 17 and 18 having different peak emission wavelengths, and the wavelength-conversion means 13 including the phosphors having peak emission wavelengths corresponding to green, orange and red light. According to the second embodiment, a color temperature of about 2000 to 7000 K and a color rendering index of 70 to 90 are manifested.

[48] FIG. 5 shows the emission spectrum of the chip package including the three light emitting diodes 16, 17 and 18 having different peak emission wavelengths and the wavelength-conversion means 13 composed of the phosphors having peak emission wavelengths corresponding to green and orange light, according to the second embodiment. The chip package has a color temperature of about 6800 K and a color rendering index of 93.

[49] The technical characteristics of the present invention, concerning FIGS. 1 to 5, are not limited only to the chip package, and may be applied to various LED packages, thus achieving the same objects and effects.

[50] Hereinafter, the embodiments in which the present techniques are applied to various LED packages are described, with reference to the appended drawings, in which the same reference numerals are used throughout the different drawings to designate the same components and structures in FIGS. 1 to 5 and the technical principles relating to the light emitting diode and the wavelength-conversion means are similarly applied.

[51] FIG. 6 is a longitudinal sectional view of a top package, according to a third embodiment of the present invention. The top package 30, which is an LED for use in a backlight unit for displays, has almost the same structure as the LEDs according to the first and second embodiments, with the exception that a reflector 31 is mounted on the substrate. The reflector 31 functions to reflect light emitted by the light emitting diode 6 in a desired direction.

[52] The top package 30 includes two light emitting diodes 6 and 7 or three light emitting diodes 16, 17 and 18, each of which has different peak emission wavelengths. Further, the top package 30 may be provided with the wavelength-conversion means 3, including a plurality of phosphors having different emission wavelengths, which are mixed with each other at one of various ratios. Such a wavelength-conversion means 3 may be dotted on the light emitting diode 6 in the reflector 31 or uniformly distributed in the resin molded part 10.

[53] FIG. 7 is a perspective view showing a side package according to a fourth embodiment of the present invention. The side package 40 has almost the same structure as the top package of FIG. 6, with the exception that its outer appearance is shaped in a very thin rectangle. A detailed description of the side package 40 according to the fourth embodiment refers to the description related to FIG. 6.

[54] In the embodiments shown in FIGS. 1 to 7, the substrate 1 formed of metal having high heat conductivity is used to readily emit heat generated when operating the light emitting diodes 6 and 7 or 16, 17 and 18. Thereby, a high output LED can be obtained. Further, when a radiation sheet (not shown) is additionally attached on the substrate, heat may be effectively radiated from the light emitting diodes 6 and 7 or 16, 17 and 18.

[55] FIG. 8 is a longitudinal sectional view showing a lamp package according to a fifth embodiment of the present invention. The lamp package 50 includes a pair of lead electrodes 51 and 52. A diode holder 53 is formed at an upper end of the lead electrode 51. The diode holder 53 is cup-shaped, in which two light emitting diodes 6 and 7 or three light emitting diodes 16, 17 and 18 are mounted. The light emitting diodes 6 and

7 or 16, 17 and 18 have different peak emission wavelengths, as in the above embodiments. The electrodes of the light emitting diodes 6 and 7 or 16, 17 and 18 are connected to the other lead electrode 52 by means of the conductive wire 2.

[56] The inner wall of the cup-shaped holder 53 is coated with an epoxy resin 54 mixed with a predetermined amount of wavelength-conversion means 3 or 13. The wavelength-conversion means 3 includes a plurality of phosphors having different peak emission wavelengths, which are mixed with each other at an appropriate ratio, as in the above embodiments. Further, each phosphor may consist of one or more phosphor components having predetermined peak emission wavelengths in the corresponding wavelength range.

[57] The outer portion of the holder 53 including the light emitting diodes 6 and 7 or 16, 17 and 18 and the wavelength-conversion means 3 or 13 is molded with the resin, for example, epoxy or silicone.

[58] FIG. 9 is a longitudinal sectional view schematically showing a high output package according to a sixth embodiment of the present invention. The high output package 60 includes a plurality of separate heat sinks 61 and 62 on which the light emitting diodes 6 and 7 or 16, 17 and 18 are mounted, and a housing 63 wherein the wavelength-conversion means 3 is placed on the upper surfaces and side surfaces of the light emitting diodes 6 and 7. A plurality of lead frames 64 to which external power is supplied protrude externally from the housing 63.

[59] FIG. 10 is a longitudinal sectional view schematically showing a high output package according to a seventh embodiment of the present invention. In the package 70, a single heat sink 71 is partially received in a housing 73 to be exposed. Also, a pair of lead frames 74 protrudes externally. The light emitting diodes 6 and 7 or 16, 17 and 18 are mounted on the heat sink 71 and connected to the lead frames 74 through the conductive wire (not shown). In addition, the wavelength-conversion means 3 or 13 is placed on the upper surface and side surfaces of the light emitting diode 6.

[60] In the high output package 60 or 70 according to the sixth and seventh embodiments of the present invention, the wavelength-conversion means 3 is placed at an adhesion portion between the heat sinks 61 and 62 or 71 and the light emitting diodes 6 and 7 or 16, 17 and 18. A lens may be mounted on the housing 63 or 73. The package 70 according to the seventh embodiment is advantageous because its height can be minimized, compared to the package 60 according to the sixth embodiment.

[61] In the case where the two light emitting diodes 6 and 7 are included in the high output package 60 or 70, the first light emitting diode having a peak emission wavelength between 390 and 450 nm and the second light emitting diode having a peak emission wavelength between 440 and 500 nm may be used. As such, the wavelength-conversion means includes a first phosphor having a peak emission

wavelength between 440 and 500nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, and a third phosphor having a peak emission wavelength between 580 and 700 nm, which are mixed with each other at an appropriate ratio.

[62] In the case where the three light emitting diodes 16, 17 and 18 are included, the first light emitting diode has a peak emission wavelength between 360 and 420 nm, the second light emitting diode has a peak emission wavelength between 400 and 450 nm, and the third light emitting diode has a peak emission wavelength between 430 and 500 nm. As such, the wavelength-conversion means includes a first phosphor having a peak emission wavelength between 440 and 500nm, a second phosphor having a peak emission wavelength between 500 and 590 nm, and a third phosphor having a peak emission wavelength between 580 and 700 nm, which are mixed with each other at an appropriate ratio.

[63] In the high output package 60 or 70, it is preferable that the radiation sheet (not shown) be separately or integrally mounted on the heat sinks 61 and 62 or 71. Then, when each light emitting diode is operated by high input power, heat generated by each light emitting diode can be effectively emitted. The radiation sheet may be cooled by means of passive air circulation or forcible circulation using a fan.

[64] In the high output package 60 or 70, when external power is supplied, each light emitting diode primarily emits light at the corresponding peak wavelengths. Then, while the phosphors are excited by primary light, they produce secondary light at the corresponding peak emission wavelengths. At this time, the primary light generated by each light emitting diode is combined with the secondary light converted into predetermined wavelengths by the phosphors to realize the color of the corresponding visible light wavelength range. Further, when the mixing ratios of the phosphors are appropriately controlled, the desired color on the color coordinate system can be easily realized.

[65] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes using two or three light emitting diodes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible by using at least one light emitting diode, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Industrial Applicability

[66] As described hereinbefore, the present invention provides an LED having a relatively high color temperature of 2,000 to 8,000 K or 10,000 K and a high color rendering index of 90 or more, by appropriately controlling the mixing ratios of the phosphors having different peak emission wavelengths or selectively using the light emitting diodes having different peak emission wavelengths.

[67] Since the LED of the present invention having high color temperature and color rendering properties functions to easily realize the desired emission on the color coordinate system, it can be variously applied to mobile phones, notebook computers, and keypads or backlight units for various electronic products. In particular, the LED can be used for automobiles and exterior and interior lighting fixtures.

Claims

[1] 1. A light emitting device, comprising:
one or more light emitting diodes to primarily emit light having different wavelengths in a wavelength range of ultraviolet rays and/or blue light; and
a wavelength-conversion means to convert the primary light into secondary light in a visible light wavelength range.

[2] 2. The device according to claim 1, wherein the one or more light emitting diodes include:
a first light emitting diode having a peak emission wavelength between 360 and 420 nm;
a second light emitting diode having a peak emission wavelength between 400 and 450 nm; and
a third light emitting diode having a peak emission wavelength between 430 and 500 nm.

[3] 3. The device according to claim 1, wherein the one or more light emitting diodes include:
a first light emitting diode having a peak emission wavelength between 390 and 450 nm; and
a second light emitting diode having a peak emission wavelength between 440 and 500 nm.

[4] 4. The device according to any one of claims 1 to 3, wherein the light emitting diodes to emit primary light and the wavelength-conversion means are mounted in a single package.

[5] 5. The device according to any one of claims 1 to 3, wherein the wavelength-conversion means comprises one or more phosphors having different properties.

[6] 6. The device according to any one of claims 1 to 3, wherein the wavelength-conversion means is placed on at least one of a side surface, an upper surface, and a lower surface of the light emitting diode, or is used in a mixture with an adhesive or a molding material.

[7] 7. The device according to any one of claims 1 to 3, wherein the wavelength-conversion means includes any one selected from among
a first phosphor having a peak emission wavelength between 440 and 500 nm,
a second phosphor having a peak emission wavelength between 500 and 590 nm,
a third phosphor having a peak emission wavelength between 580 and 700 nm,
and mixtures thereof.

[8] 8. The device according to claim 7, wherein each phosphor includes one or more phosphor components having different properties in the corresponding

wavelength range.

[9] 9. The device according to claim 4, wherein the single package is formed into a chip package, which comprises a substrate, one or more light emitting diodes mounted on the substrate, and a wavelength-conversion means placed around the light emitting diodes.

[10] 10. The device according to claim 4, wherein the single package is formed into a top package, which comprises a substrate having a reflector formed thereon, one or more light emitting diodes mounted on the substrate, and a wavelength-conversion means placed around the light emitting diodes.

[11] 11. The device according to claim 9, wherein the substrate is formed of metal to emit heat generated by the one or more light emitting diodes.

[12] 12. The device according to claim 11, further comprising a radiation sheet mounted on the substrate formed of metal.

[13] 13. The device according to claim 9, further comprising a molded part to enclose the light emitting diodes and the wavelength-conversion means on the substrate.

[14] 14. The device according to claim 13, wherein the wavelength-conversion means is uniformly distributed in the molded part.

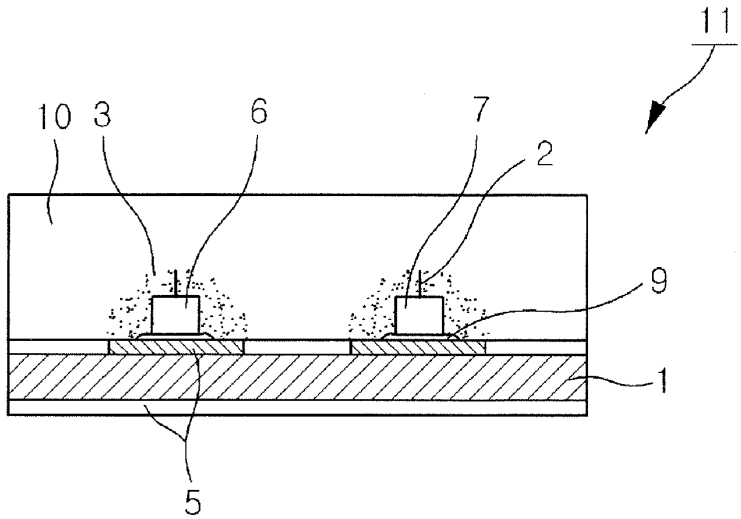
[15] 15. The device according to claim 4, wherein the single package is formed into a lamp package, which comprises a pair of lead electrodes, one or more light emitting diodes mounted on one of the pair of lead electrodes, a wavelength-conversion means placed around the light emitting diodes, and a molded part to enclose the light emitting diodes and the wavelength-conversion means.

[16] 16. The device according to claim 4, wherein the single package is formed into a high output package, which comprises one or more light emitting diodes, a wavelength-conversion means placed around the light emitting diodes, and a heat sink to emit heat generated by the light emitting diodes.

[17] 17. The device according to claim 16, further comprising a radiation sheet to emit heat from the heat sink.

[18] 18. The device according to any one of claims 1 to 3, wherein the light emitting diodes each include a substrate formed of silicon carbide or sapphire and a nitride epitaxial layer formed on the substrate.

[Fig. 1]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1
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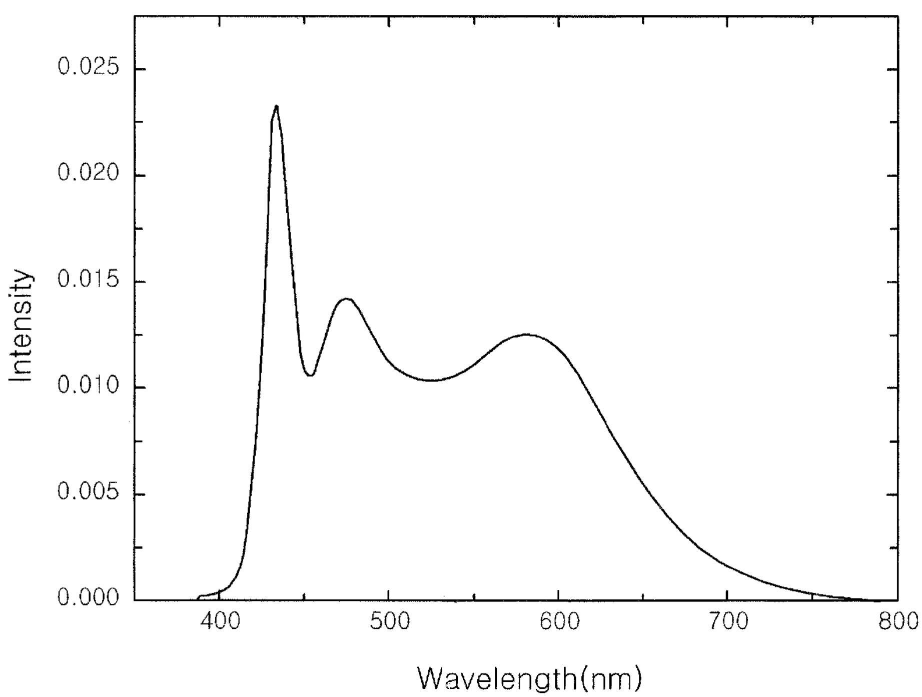
[Fig. 2]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700
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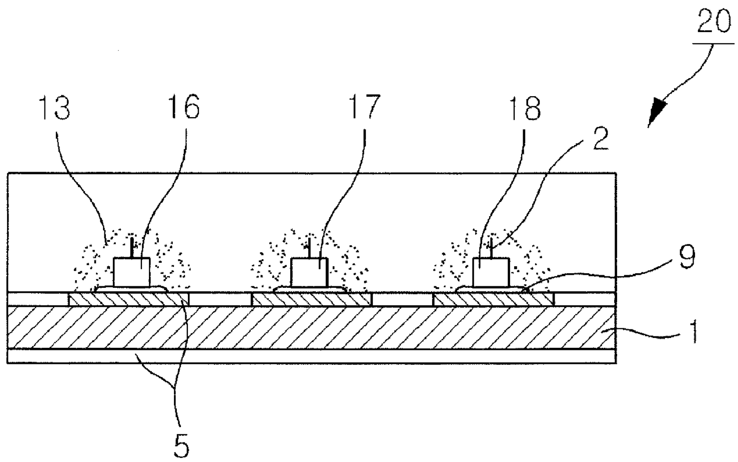
Wavelength(nm)

[Fig. 3]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18
2
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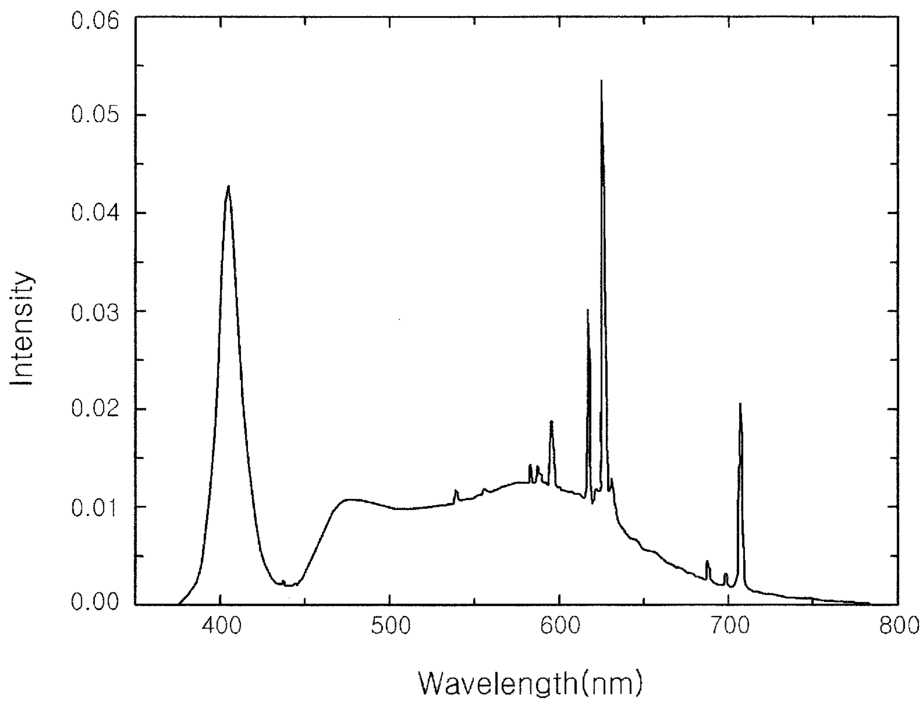
5

[Fig. 4]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Intensity
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700
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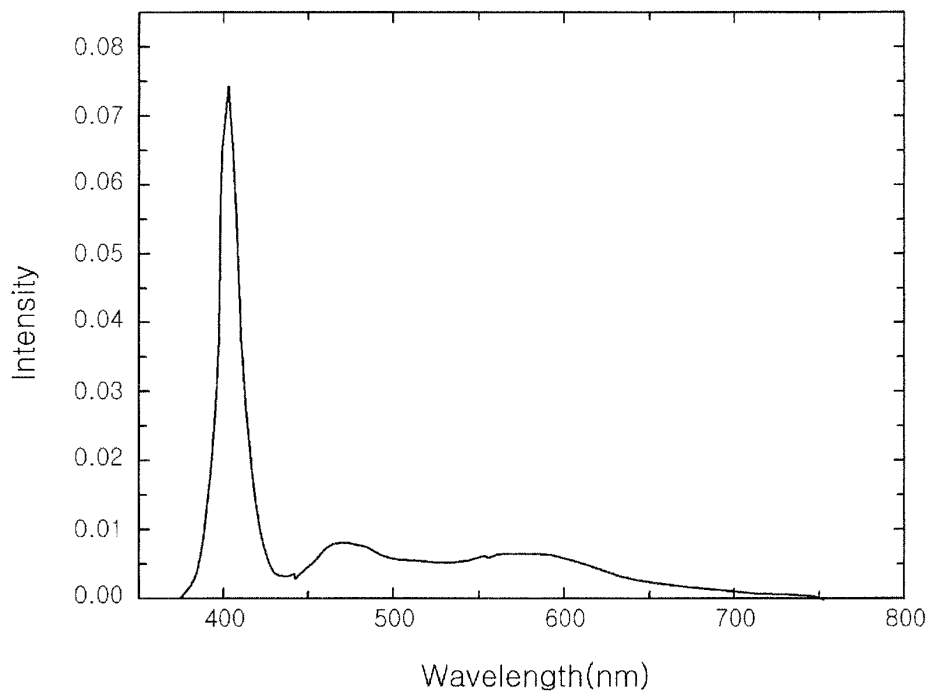
Wavelength(nm)

[Fig. 5]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Intensity
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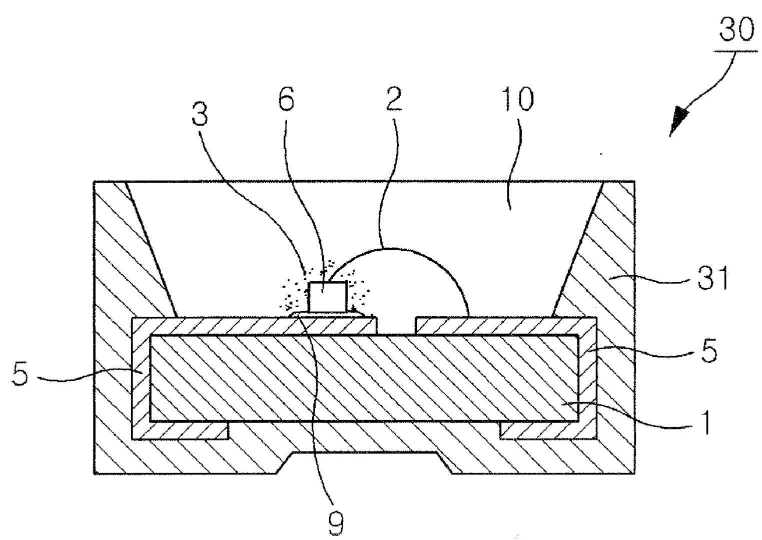
Wavelength(nm)

[Fig. 6]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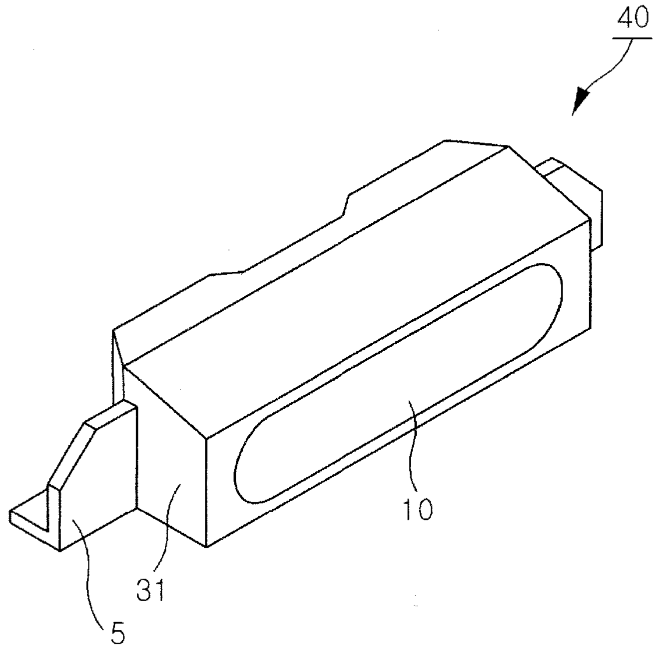
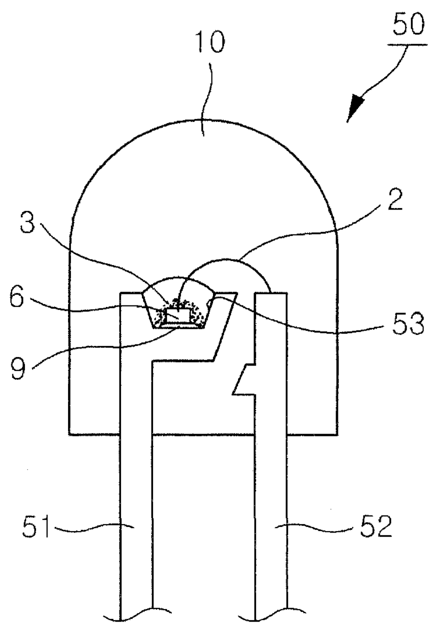
9

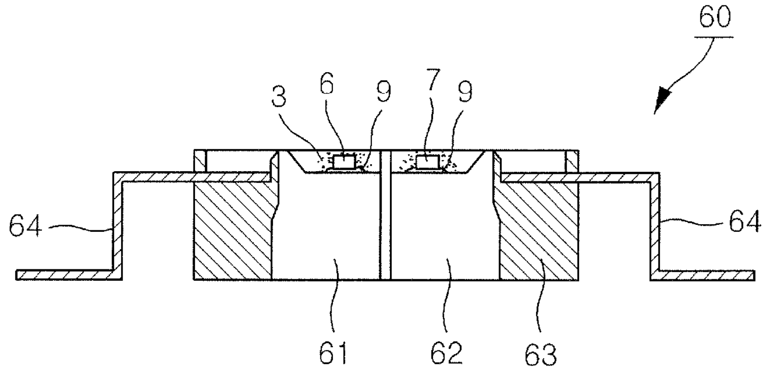
[Fig. 7]



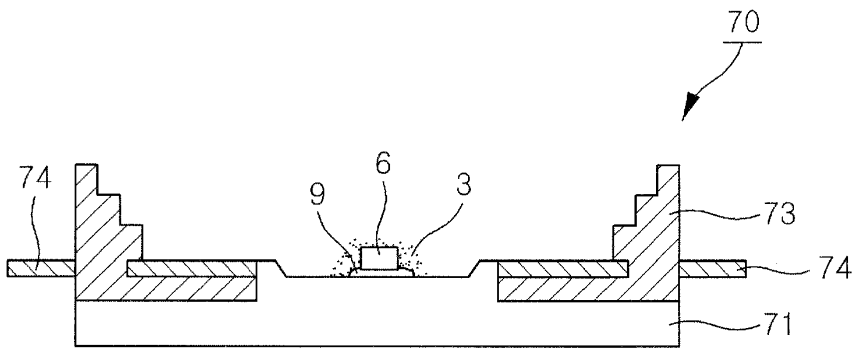
[Fig. 8]



[Fig. 9]



[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/001287

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 H01L 33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01L, C09K, F21V, G09F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975
Korean Utility models and applictions for Utility models since 1975
Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the intertnational search (name of data base and, where practicable, search terms used)
e-KIPASS: "white", "LED", "UV", "blue", "phosphor"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 9-153644 A (TOYODA GOSEI CO., LTD) 10 JUNE 1997 see the abstract, claim 1	1, 7-8 2-6, 9-18
X A	US 6686691 B1 (LUMILEDS LIGHTING LLC.) 3 FEBRUARY 2004 see rhe abstract, figures 1-3	1, 4-6, 9-10, 13-15, 18 2-3, 7-8, 11-12,16-17
X Y A	JP 2004-127988 A (TOYODA GOSEI CO. LTD.) 22 APRIL 2004 see paragraphs [004]~[0006], figure 10	1, 4-10, 13-15, 18 11-12, 16-17 2-3
X Y A	JP 2003-224306 A (SOLIDLITE CORP) 8 AUGUST 2003 see the abstract, claims 1-4, figures 1-5	1, 4-10, 13-15, 18 11-12, 16-17 2-3
Y A	JP 2002-359403 A (NICHIA CHEM. IND. LTD.) 13 DECEMBER 2002 see the abstract, claims 1-12, figure 1-12	11-12, 16-17 2-3

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 AUGUST 2005 (12.08.2005)	**12 AUGUST 2005 (12.08.2005)**

Name and mailing address of the ISA/KR
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Republic of Korea
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2005/001287

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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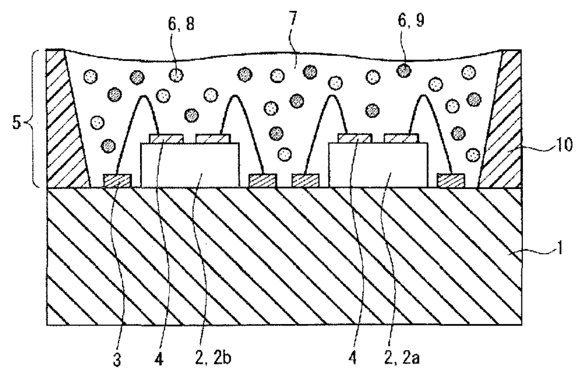
(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title**: SEMICONDUCTOR LIGHT EMITTING DEVICE AND BACKLIGHT SOURCE, BACKLIGHT SOURCE SYSTEM, DISPLAY DEVICE, AND ELECTRONIC DEVICE USING THE SAME

[Fig. 1]



(57) **Abstract**: The semiconductor light emitting device of the present invention emits a blue light component, a green light component, and a red light component. The blue light component is a light component emitted by a first solid light emitting element that emits light having an emission peak in a wavelength range of 430 nm to less than 490 nm, the green light component is light emitted by a second solid light emitting element that emits light having an emission peak in a wavelength range of 360 nm to less than 420 nm that is converted into wavelength-converted light by a green phosphor, and the red light component is light emitted by at least one solid light emitting element selected from the first solid light emitting element and the second solid light emitting element that is converted into wavelength-converted light by a red phosphor. The green phosphor emits green light on the basis of an electronic energy transition of Mn^{2+}.

WO 2010/023840 A1

Description

Title of Invention: SEMICONDUCTOR LIGHT EMITTING DEVICE AND BACKLIGHT SOURCE, BACKLIGHT SOURCE SYSTEM, DISPLAY DEVICE, AND ELECTRONIC DEVICE USING THE SAME

Technical Field

[0001] The present invention relates to all-solid semiconductor light emitting devices, and backlight sources, backlight source systems, display devices such as a liquid crystal display, and electronic devices using the all-solid light emitting devices.

Background Art

[0002] Conventionally, there have been known semiconductor light emitting devices (hereinafter referred to as wavelength-converted RGB solid light sources) configured to emit at least light components of the three primary colors, red (R), green (G) and blue (B), with the combined use of solid light emitting elements (e.g., light emitting diodes, hereinafter referred to as LEDs) and phosphors that absorb primary light emitted by the solid light emitting elements and convert the primary light into light with a longer wavelength.

[0003] Examples of conventionally-known combination structures of the wavelength-converted RGB solid light sources are as follows.

(1) A combination structure including an ultraviolet LED and red, green and blue phosphors (see Patent document 1, for example)

(2) A combination structure including a blue LED and green and red phosphors (see Patent document 2, for example)

(3) A combination structure including an ultraviolet LED, a blue LED, and red and green phosphors (see Patent document 10, for example)

(4) A combination structure including a blue LED, a green phosphor and a red LED (see Patent document 3, for example)

(5) A combination structure including a blue LED, a green (lime green) phosphor, a green LED and a red phosphor (see Patent document 4, for example)

(6) A combination structure including a blue LED, a green LED and a red phosphor (see Patent document 5, for example)

(7) A combination structure including an ultraviolet LED, blue and green phosphors and a red LED (see Patent document 6, for example)

[0004] In addition to the combination structures described above, there also has been invented a combination structure including an LED having light emitting layers that emit two kinds of light with different wavelengths, and phosphors, for example (see Patent document 7, for example).

[0005] These conventional semiconductor light emitting devices are created primarily as illumination light sources, and from most of them, each wavelength component is outputted in a state of being adjusted so that light with an arbitrary color temperature or light with a light bulb color, for example, can be emitted (see Patent documents 5 and 8, for example).

[0006] Applications of the wavelength-converted RGB solid light sources to backlights for display devices (e.g., backlights for liquid crystal displays) also have been pursued. For example, applications of a combination structure of an ultraviolet LED and red, green and blue phosphors, a combination structure of a blue LED and green and red phosphors, and a combination structure of an ultraviolet/violet LED, a blue LED, and green and red phosphors, etc. have been studied, and liquid crystal displays, etc. using such backlight sources also have been proposed (see Patent documents 9 and 10, for example).

[0007] In a wavelength-converted RGB solid light source having the above-described combination structure including an ultraviolet/violet LED, a blue LED, and green and red phosphors, the green phosphor that emits green light and the red phosphor that emits red light both have broadband light absorption properties. This light source is created to solve the problem of an absorption loss of blue light, which occurs due to the blue light not being absorbed entirely but only partially, and high output is achieved particularly by the excitation of a green phosphor activated with Eu^{2+} or a red phosphor activated with Eu^{2+} having an excitation peak in a near-violet - violet wavelength range of 300 to less than 420 nm with excitation light in the region of the excitation peak.

[0008] Accordingly, this light source is based on the premise that a phosphor made of $SrAl_2O_4:Eu^{2+}$, Eu^{2+}-based thiogallate (e.g., $SrGa_2S_4:Eu^{2+}$) or the like, for example, having an absorption spectrum shifted toward a blue wavelength range and also having broadband light absorption properties in a near-ultraviolet - blue wavelength range [e.g., a phosphor activated with Eu^{2+} that emits green light on the basis of a $(4f)^7$ - $(4f)^6 5d^1$ electronic energy transition of Eu^{2+}] is used as the green phosphor, not a green phosphor that substantially does not absorb blue light [e.g., a phosphor that emits green light on the basis of a $(3d)^5$ - $(3d)^5$ electronic energy transition of Mn^{2+}].

[0009] Furthermore, a structure in which the above-described green phosphor does not cover a light extraction surface of the blue LED is considered to be a preferred form, and specifically, a structure in which the green phosphor and the red phosphor are at least separated spatially from the blue LED has been proposed.

[0010] It should be noted that a highly-precise measurement technique for absolute external quantum efficiency and absolute internal quantum efficiency of phosphors, which will be mentioned in this specification, already has been established and the efficiencies can be evaluated with the use of phosphor samples (see Non-patent document 1, for example).

Citation List

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PTL 3: JP 2005-285920 A
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PTL 5: JP 2006-324653 A
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PTL 7: JP 2006-216926 A
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PTL 9: JP 2007-96133 A
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Non Patent Literature

[0012] NPL 1: Kazuaki Okubo et al., "Journal of The Illuminating Engineering Institute of Japan", 1999, Vol. 83, No. 2, p. 87

Summary of Invention

Technical Problem

[0013] However, with the conventional wavelength-converted RGB solid light sources, it is generally difficult to obtain highly practical display devices having excellent RGB purity, and both a wider range of color expression and high luminance, all of which are required of liquid crystal displays and liquid crystal televisions.

[0014] The root cause of this problem is that high-power solid light emitting elements that emit ultraviolet light are still under development. Hereinafter, this root cause will be described in detail.

[0015] In wavelength-converted RGB solid light sources, although solid light emitting elements function as excitation sources for phosphors, the choices for electromagnetic waves emitted by the solid light emitting elements technically are limited to four types; deep-ultraviolet, near-ultraviolet, violet light, and blue light. However, in view of the technical maturity, solid light emitting elements having advantages in both production cost and light output performance are limited to solid light emitting elements that emit blue light. Accordingly, semiconductor light emitting devices that heavily use a blue LED as an excitation source are the only light emitting devices useable as backlight sources that satisfy the market demands.

[0016] On the other hand, in white LEDs using a blue LED as a phosphor excitation source, for example, since the energy difference between blue light as excitation light and visible light as wavelength-converted light is relatively small, the number of phosphors that can be excited with a high degree of efficiency is limited due to the physical properties of phosphors.

[0017] In the case of green phosphors in particular, due to an extremely small energy difference between light absorption and light emission (the energy difference between blue absorption light and green emission light), green phosphors that satisfy a number of practical conditions are limited only to a few types of phosphors activated with Eu^{2+} or Ce^{3+}.

[0018] From a phosphor activated with Eu^{2+} and a phosphor activated with Ce^{3+} used selectively as described above, emission light is obtained on the basis of a $(4f)^n$ - $(4f)^{n-1}5d^1$ electronic energy transition of Eu^{2+} ions or Ce^{3+} ions [n = 1(Ce^{3+}), n = 7(Eu^{2+})]. Thus, their light emission spectrum half-width becomes relatively large due to their light emission mechanisms.

[0019] As a result, at least a green light component in output light has a large spectrum half-width of 65 nm or more for a backlight source. Accordingly, it is essentially difficult to increase the color range of the display device.

[0020] Particularly, as far as green phosphors activated with Eu^{2+} are concerned, the green phosphors activated with Eu^{2+} generally have an excitation peak in a near-violet - violet wavelength range of 300 nm to less than 420 nm. Therefore, when a blue LED is used as an excitation source for the phosphors, the phosphors cannot be used in a state where their properties are in the best condition. That is, since the phosphors are excited by light having a wavelength shifted toward the long wavelength side from the excitation peak, they cannot exhibit adequate performance. As a result, generally, a green light component in the output light is likely to be poor in light emission efficiency. Thus, when such a green phosphor is used in a semiconductor light emitting device, the luminance of the semiconductor light emitting device tends to be poor.

[0021] When the green phosphor activated with Eu^{2+} and the red phosphor activated with Eu^{2+} are excited with a high degree of efficiency by a near-violet or violet LED that emits light having a wavelength of 300 to 420 nm where the phosphors have their excitation peak, the semiconductor light emitting device can achieve high output. However, since the green light component and the red light component have a large spectrum half-width due to the reasons described above, not only does each light become poor in color purity when RGB light components are separated using each of red, green and blue color filters, but also the color range becomes small when images are displayed. Thus, it is difficult to increase the color range of the display device.

[0022] On the other hand, efforts have been made to apply a plurality of types of LEDs with significantly different emission light colors (e.g., a combination of a blue LED, a green

LED and a red LED, a combination of a blue LED and a green LED, and a combination of a blue LED and a red LED) for reducing the spectrum half-width of each light component of RGB. In this case, however, a circuit configuration for favorably balancing the colors of RGB becomes complicated, and it is difficult to put this configuration to practical use.

[0023] This is due to an essential problem that at least two types of solid light emitting elements having light emitting layers of different material systems (e.g., InGaN and GaP, InGaN and AlGaAs, etc.) need to be used in combination in order to obtain, among red, green and blue, at least two emission light colors that are significantly different from each other in color tone.

[0024] When a plurality of types of LEDs of different material systems are used, due to their differences in input power - light output properties, it is difficult to maintain a color balance during gradation display, for example. Thus, in order to maintain a desired color balance, the balance needs to be attended by the driver circuit side, thereby complicating the circuit configuration of the backlight source.

Solution to Problem

[0025] In order to solve the above-described problems, the present invention provides, with the use of solid light emitting elements having light emitting layers of the same material system, a wavelength-converted RGB solid light source, etc. that emits high-power (high-luminance) RGB light suitable for a liquid crystal backlight, and in particular, a wavelength-converted RGB solid light source, etc. that emits at least a blue light component and a green light component having a small spectral radiation bandwidth and have a wider range of excellent color expression.

[0026] The semiconductor light emitting device of the present invention is a semiconductor light emitting device that emits: a blue light component having an emission peak in a wavelength range of 430 nm to less than 490 nm; a green light component having an emission peak in a wavelength range of 500 nm to less than 550 nm, and a red light component having an emission peak in a wavelength range of 600 nm to less than 660 nm. The blue light component is a light component emitted by a first solid light emitting element that emits light having an emission peak in a blue wavelength range of 430 nm to less than 490 nm. The green light component is light emitted by a second solid light emitting element that emits light having an emission peak in a near-ultraviolet - violet wavelength range of 360 nm to less than 420 nm that is converted into wavelength-converted light by a green phosphor. The red light component is light emitted by at least one solid light emitting element selected from the first solid light emitting element and the second solid light emitting element that is converted into wavelength-converted light by a red phosphor. The green phosphor emits green light on the basis of an electronic energy transition of Mn^{2+}.

[0027] Each of a backlight source and a backlight source system of the present invention includes the semiconductor light emitting device of the present invention.

[0028] A display device of the present invention includes the backlight source or the backlight source system of the present invention.

[0029] An electronic device of the present invention includes the display device of the present invention.

Advantageous Effects of Invention

[0030] According to the present invention, it is possible to provide a highly practical wavelength-converted RGB solid light source, a backlight source, etc. capable of increasing both a color range and luminance of a display device. Further, it is also possible to provide a display device, in particular, a liquid crystal display panel using the wavelength-converted RGB solid light source capable of increasing both a color range and luminance, and an electronic device using the liquid crystal display panel.

Brief Description of Drawings

[0031] [fig.1]FIG. 1 is a cross-sectional view schematically showing one example of the semiconductor light emitting device of the present invention.

[fig.2]FIG. 2 is a cross-sectional view schematically showing one example of the semiconductor light emitting device of the present invention.

[fig.3]FIG. 3 is a cross-sectional view schematically showing one example of the semiconductor light emitting device of the present invention.

[fig.4]FIG. 4 is a cross-sectional view schematically showing one example of the semiconductor light emitting device of the present invention.

[fig.5]FIG. 5 is a cross-sectional view schematically showing one example of the semiconductor light emitting device of the present invention.

[fig.6]FIG. 6 is a diagram showing one example of a spectral distribution of output light emitted by the semiconductor light emitting device of the present invention.

[fig.7]FIG. 7 is a diagram showing one example of a spectral distribution of output light emitted by the semiconductor light emitting device of the present invention.

[fig.8]FIG. 8 is a schematic view showing one example of the backlight source of the present invention.

[fig.9]FIG. 9 is a schematic view showing one example of the backlight source system of the present invention.

[fig.10]FIG. 10 is a schematic view showing one example of the display device of the present invention.

[fig.11]FIG. 11 is a schematic view showing one example of a liquid crystal television set as a representative example of the electronic device of the present invention.

Description of Embodiments

[0032] Hereinafter, embodiments of the present invention will be described with reference to the drawings. However, the present invention is not limited to the following embodiments. In each of the drawings, the same components are denoted by the same reference numerals and overlapping descriptions may not be repeated.

[0033] (Embodiment 1)

First, an embodiment of the semiconductor light emitting device of the present invention will be described. FIGS. 1 to 5 are cross-sectional views, each schematically showing one example of the semiconductor light emitting device of the present invention. Although FIGS. 1 to 5 are cross-sectional views, solid light emitting elements 2 and a translucent resin 7 are not denoted with hatching that indicates a cross section, to improve the viewability of the drawings. FIGS. 6 and 7 are diagrams each showing a representative example of spectral distribution of output light emitted by the semiconductor light emitting device of the present invention.

[0034] In FIGS. 1 to 5, a substrate 1 is a base to which the solid light emitting elements 2 are fixed, and it is made of, for example, ceramics (Al_2O_3, AlN, etc.), metal (Al, Cu, etc.), glass, a resin (silicone resin, filler-containing silicone resin, etc.) or the like.

[0035] Further, wiring conductors 3 are provided on the substrate 1. By electrically connecting feeding electrodes 4 of the solid light emitting elements 2 with the wiring conductors 3, power is supplied to the solid light emitting elements 2.

[0036] The solid light emitting elements 2 are photoelectric conversion elements that convert electric energy into light energy by a power supply that applies a voltage selected from at least AC, DC, and pulse voltages, and they are, for example, LEDs, laser diodes (LDs), inorganic electroluminescence (EL) elements, or organic EL elements, etc. LEDs or LDs can be used preferably as the solid light emitting elements 2 for obtaining high-power primary light with a small spectrum half-width.

[0037] Wavelength conversion layers 5 include a phosphor 6 made of a fluorescent material, and they convert primary light emitted by the solid light emitting elements 2 into light having a longer wavelength than the primary light. The wavelength conversion layers 5 are made of, for example, a resin phosphor film, translucent fluorescent ceramics, fluorescent glass, etc. In the present embodiment, the wavelength conversion layers 5 are formed by a resin phosphor film made by dispersing the phosphor 6 in a translucent resin 7.

[0038] The semiconductor light emitting device of the present invention emits, as can be seen from the example of spectral distribution of the output light shown in FIGS. 6 and 7, a blue light component 12 having an emission peak in a wavelength range of 430 nm to less than 490 nm, preferably 440 nm to less than 470 nm, a green light component

13 having an emission peak in a wavelength range of 500 nm to less than 550 nm, and a red color component 14 having an emission peak in a wavelength range of 600 nm to less than 660 nm.

[0039] The blue light component 12 is a light component emitted by a first solid light emitting element 2a that emits light having an emission peak in a blue wavelength range of 430 nm to less than 490 nm. The green light component 13 is light emitted by a second solid light emitting element 2b that emits light having an emission peak in a near-ultraviolet - violet wavelength range of 360 nm to less than 420 nm, preferably in a violet wavelength range of 380 nm to less than 410 nm that is converted into wavelength-converted light by a green phosphor 8. The red light component 14 is light emitted by at least one light emitting element selected from the first solid light emitting element 2a and the second light emitting element 2b that is converted into wavelength-converted light by a red phosphor 9 (FIGS. 1 to 5).

[0040] The green phosphor 8 emits green light on the basis of an electronic energy transition of Mn^{2+} [$(3d)^5$ - $(3d)^5$ electronic energy transition]. Furthermore, it is preferable that the green phosphor 8 is a green phosphor that substantially does not absorb blue light having a wavelength of 450 nm and does not get excited by the blue light.

[0041] It is assumed that the phrase "substantially does not absorb blue light having a wavelength of 450 nm and does not get excited by the blue light" refers to a state where absolute external quantum efficiency is less than 10 % under excitation by the blue light having a wavelength of 450 nm at ambient temperature. Here, the absolute external quantum efficiency refers to a ratio between the quantum number of excitation light with which the phosphor is irradiated and the quantum number of light emitted by the phosphor, and a method of measuring the absolute external quantum efficiency is described in Non-patent document 1 mentioned above.

[0042] In FIGS. 6 and 7, a near-ultraviolet - violet light component 11 is a leakage of primary light emitted by the second solid light emitting element 2b.

[0043] In this way, by using the first solid light emitting element 2a that emits light having an emission peak in a blue wavelength range and the second solid light emitting element 2b that emits light having an emission peak in a near-ultraviolet - violet wavelength range in combination, at least the green phosphor 8 is excited not by blue light emitted by the first solid light emitting element 2a but by near-ultraviolet or violet light emitted by the second solid light emitting element 2b. Thus, the energy difference between light absorption and light emission (the energy difference between near-violet - violet absorption light and green emission light) of the green phosphor 8 increases, and as a result, the green phosphor 8 can be selected from a wide range of choices.

[0044] Consequently, green phosphors that do not absorb the blue light and substantially do not get excited by the blue light can be used, and phosphors other than green phosphors activated with Eu^{2+}, Ce^{3+}, etc. can also be used.

[0045] Further, in a preferred embodiment of the present invention, since the green phosphor 8 does not absorb blue light having a wavelength in the region of 450 nm and does not get excited by the blue light, blue light emitted by the first solid light emitting element 2a does not interfere with the device. Consequently, it is possible to achieve a semiconductor light emitting device suitable for industrial production that outputs light whose color tone can be adjusted or controlled with relative ease.

[0046] Further, by using a phosphor that emits green light on the basis of a $(3d)^5$ - $(3d)^5$ electronic energy transition of Mn^{2+} as the green phosphor 8, the spectrum half-width of the green light component 13 becomes less than 60 nm, and as a result, the intensity of a blue-green emission light component in the region of 490 nm and a yellow emission light component in the region of 575 nm becomes small, as shown in FIGS. 6 and 7.

[0047] In this way, the energy intensity of both the blue-green light and the yellow light can be reduced to 30 % or less, and in a preferred embodiment, 20 % or less of the peak of the spectral distribution of the output light, so that not only the boundaries of blue light and green light and green light and red light become clear, but also light output components centered on blue, green and red can be outputted. Thus, without relying heavily on a design technique of color filters, it is possible to separate red, green and blue clearly and to increase a light output that passed through the color filters. As a result, the device configuration becomes suitable for industrial production.

[0048] As described above, with the semiconductor light emitting device of the present invention, it is possible to increase the color purity of each light component of RGB and to achieve high output with relative ease. Thus, a wider range of color expression with a high light output can be achieved.

[0049] Furthermore, since many of the green phosphors activated with Mn^{2+} emit green light having an emission peak in a deep-green wavelength range of 510 to 520 nm, they can convert light having an emission peak in the near-violet - violet wavelength range into green light with a high degree of photon conversion efficiency (absolute internal quantum efficiency). Thus, the semiconductor light emitting device of the present invention becomes a highly practical semiconductor light emitting device that emits the green light component 13, which is excellent in both the purity of green and light emission efficiency. Here, the photon conversion efficiency (absolute internal quantum efficiency) refers to a ratio between the quantum number of excitation light absorbed by the phosphor and the quantum number of light emitted by the phosphor, and a method of measuring the photon conversion efficiency is described in Non-patent document 1 mentioned above.

[0050] It is preferable that the green phosphor 8 that emits green light on the basis of the electronic energy transition of Mn^{2+} is a phosphor coactivated with a combination of Eu^{2+} and Mn^{2+} or a combination of Ce^{3+} and Mn^{2+}.

[0051] By constructing the green phosphor 8 in this way, Eu^{2+} or Ce^{3+} efficiently absorbs light having a near-violet - violet wavelength range of 360 nm to less than 420 nm emitted by the second solid light emitting element 2b, transfers the light to Mn^{2+}, and the absorbed near-violet or violet light is converted into green light with a high degree of photon conversion efficiency close to the theoretical limit.

[0052] Further, with the light in a near-violet - violet wavelength range emitted by the second solid light emitting element 2b, green light added with a blue light component (slightly bluish green light) based on an electronic energy transition of Eu^{2+} or Ce^{3+} (a blue light component having a relatively large spectrum half-width) also can be obtained from the green light component 13 by Mn^{2+}. Thus, it is possible subtly to control the color tone of the output light with ease.

[0053] Furthermore, by constructing the green phosphor 8 in this way, coinciding the peak wavelength of the near-violet - violet light used as the excitation light for the phosphor with the excitation peak wavelength of the green phosphor 8 becomes less necessary. Therefore, even when the peak wavelength of the excitation light shifts toward the long wavelength side relative to the excitation peak of the green phosphor 8, the near-violet or violet light can be converted into green light with photon conversion efficiency close to the theoretical limit. Hence, designing a high-power semiconductor light emitting element device becomes flexible.

[0054] For example, even if the green phosphor 8 has an excitation peak in a wavelength range of less than 360 nm and not in a near-violet - violet wavelength range of 360 nm to less than 420 nm, it still has properties capable of converting near-violet - violet light into green light with an extremely high degree of photon conversion efficiency close to the theoretical limit. Thus, it is possible to provide a high-power semi-conductor light emitting device.

[0055] Further, since most of such phosphors coactivated with Mn^{2+} and at least either Eu^{2+} or Ce^{3+} do not absorb blue light, it is possible to prevent intervention by light in a blue wavelength range emitted by the first solid light emitting element 2a, and the chromaticity of the output light can be controlled with relative ease.

[0056] Specific examples of the green phosphor 8 activated with Mn^{2+} as described above include an alkaline earth metal aluminate green phosphor coactiveated with Eu^{2+} - Mn^{2} (e.g., $BaMgAl_{10}O_{17}:Eu^{2+},Mn^{2+}$), a rare earth aluminate green phosphor coactiveated with Ce^{3+} - Mn^{2+}[e.g., $CeMgAl_{11}O_{19}:Mn^{2+}$ and $Ce(Mg, Zn) Al_{11}O_{19}:Mn^{2+}$], and the like.

[0057] In particular, the alkaline earth metal aluminate green phosphor coactiveated with Eu^{2+} - Mn^{2+} is known as a highly heat resistant phosphor with small temperature extinction, and it is a highly efficient phosphor that has been used practically in high-pressure mercury lamps, and is preferable in terms of increasing the power of the green component 13.

[0058] As described above, the phosphor coactivated with Mn^{2+} and at least either Eu^{2+} or Ce^{3+} is preferably a phosphor having not only the green light but also, to a certain extent, a blue output component based on an electronic energy transition of Eu^{2+} or Ce^{3+} in a blue wavelength range of 430 nm to less than 490 nm for controlling the color tone of output light of the semiconductor light emitting device, etc. In this case, in order not to impair the purity of blue due to the spectrum half-width of the blue light component 12 becoming too large, the green phosphor preferably is constructed such that the maximum intensity of the blue light based on an electronic energy transition of Eu^{2+} or Ce^{3+} in the blue wavelength range is about 30 % or less, preferably 20 % or less of that of the green light so as to limit the maximum intensity of the blue light to a lower value.

[0059] Furthermore, according to the present invention, with respect to the first solid light emitting element 2a and the second solid light emitting element 2b, from light emitting elements having an emission peak in a near-violet - violet - blue wavelength range of 360 nm to less than 490 nm, particularly in a violet - blue wavelength range of 380 nm to less than 470 nm, a light emitting element having an emission peak in a near-violet - violet wavelength range may be selected for the second solid light emitting element 2b and a light emitting element having an emission peak in a blue wavelength range may be selected for the first solid light emitting element 2a.

[0060] As a result, the materials for the light emitting layers of the first solid light emitting element 2a and the second solid light emitting element 2b can be selected from those of the same material system having relatively similar physical properties. When LEDs are used as the solid light emitting elements 2, they only need to be formed by a compound containing at least Ga and N. More specifically, the light emitting layer of the first solid light emitting element 2a may be formed by an InGaN compound and the light emitting layer of the second light emitting element 2b may be formed by a GaN compound.

[0061] Thus, although a plurality of types of LEDs that are slightly different from each other in the compositions of their light emitting layers are used, they are of the same material system and have similar input power-light output properties. Thus, when used for a display device, a color balance can be maintained with relative ease, and the circuit configuration of a backlight source, etc. can be simplified.

[0062] According to the present invention, by using the first solid light emitting element 2a that emits light having an emission peak in a blue wavelength range and the second solid light emitting element 2b that emits light having an emission peak in a near-violet - violet wavelength range in combination, the red phosphor 9 only needs to be a phosphor that is excited by at least one light selected from blue light emitted by the first solid light emitting element 2a and near-violet or violet light emitted by the second solid light emitting element 2b. Thus, not only red phosphors that are excited by blue light but also red phosphors that are excited by near-violet light, for which there are a relatively high number of highly-efficient phosphors, also can be used. And not only the green phosphor 8 but also the red phosphor 9 can be selected from a wide range of choices.

[0063] As a result, it is possible to use phosphors other than red phosphors activated with Eu^{2+} having a large spectral radiation bandwidth, in particular red phosphors activated with Eu^{3+} having an emission spectrum, considered to be preferable in terms of the purity of red on a display device. Thus, a semiconductor light emitting device that further emits the red light component 14 having excellent color purity and excellent light emission efficiency can be provided.

[0064] According to the present invention, the green phosphor 8 only needs to be a highly efficient phosphor with a high degree of absolute internal quantum efficiency (e.g., 80 % or more) under excitation by near-violet - violet light emitted by the second solid light emitting element 2b, and it may be a phosphor with a low degree of light emission efficiency whose absolute internal quantum efficiency under excitation by blue light emitted by the first solid light emitting element 2a is less than 50 %, in particular less than 10 %.

[0065] Examples of such a green phosphor 8 include the alkaline earth metal aluminate phosphor coactiveated with Eu^{2+} - Mn^{2+} (e.g., $BaMgAl_{10}O_{17}:Eu^{2+},Mn^{2+}$) for example, and such a phosphor is used as the green phosphor in the present invention.

[0066] In the semiconductor light emitting device of the present invention, it is preferable that the radiation bandwidth of the blue light component 12 is in a range of 20 nm to less than 40 nm and the radiation bandwidth of the green light component 13 is in a range of 20 nm to less than 60 nm. Consequently, not only is it possible that at least the blue light component 12 and the green light component 13 have a small spectral radiation bandwidth and excellent color purity, but also the intensity of blue-green and yellow emission light components can be reduced. Thus, the semiconductor light emitting device of the present invention becomes preferable for a wider range of color expression with high blue and green light outputs.

[0067] With respect to such a blue light component 12, primary light emitted by the first solid light emitting element 2a, such as a blue LED, that passed through the wavelength conversion layer 5 may be used partially or entirely in its natural state as the blue light component 12 of the output light.

[0068] It should be noted that unlike light emitted by a phosphor, the blue light component 12 emitted by the blue LED is light with strong directivity. Thus, it is preferable that at least primary light emitted by the first solid light emitting element 2a is outputted through a light diffusion layer having a light diffusion effect. Examples of such a light diffusion layer include a translucent sheet or the like on which a particle group, such as an inorganic powder and a resin power, is dispersed. Phosphors (the green phosphor 8 and/or the red phosphor 9) also can be used as the particle group. By configuring in this way, the directivity of the blue light component 12 is relieved and the blue light component 12 is outputted as light that is dispersed in a relatively uniform manner similar to wavelength-converted light emitted by a phosphor. Consequently, white light with suppressed unevenness in its color (color separation) suitable for an illumination light source or a display device can be obtained.

[0069] On the other hand, the green light component 13 having such a small spectrum half-width only can be obtained from at least phosphors activated with Mn^{2+} ions based on an electronic energy transition of the Mn^{2+} ions, such as the $BaMgAl_{10}O_{17}:Eu^{2+},Mn^{2+}$ green phosphor, for example.

[0070] In the semiconductor light emitting device of the present invention, it is preferable that the light emitting layer of the first solid-light emitting element 2a and the light emitting layer of the second solid light emitting element 2b are both made of a compound containing Ga and N, as described above. Consequently, high-power near-violet - violet and blue primary light can be obtained and a high-power semiconductor light emitting device can be achieved.

[0071] Further, in order to achieve both a wider range of color and high luminance, it is preferable that, in the semiconductor light emitting device of the present invention, the red phosphor 9 is at least one of a nitride phosphor or an oxynitride phosphor activated with Eu^{2+} (hereinafter referred to as nitride phosphors) and an oxide phosphor or an oxysulfide phosphor activated with Eu^{3+}.

[0072] It has been known that such a red phosphor 9 emits light with a high degree of efficiency by near-violet - violet and/or blue light excitation, and its photon conversion efficiency (absolute inner quantum efficiency) is at a level of more than 80 %. Therefore, it is possible to provide a semiconductor light emitting device capable of increasing the luminance of a display device.

[0073] Examples of the nitride phosphors activated with Eu^{2+} include an alkaline earth metal nitride aluminosilicate phosphor activated with Eu^{2+}, an alkaline earth metal nitride silicate phosphor activated with Eu^{2+}, an alkaline earth metal oxynitride aluminosilicate phosphor activated with Eu^{2+} and the like, and they are, for example, red phosphors expressed by the following chemical formulas.

[0074] (1) $MAlSiN_3:Eu^{2+}$

(2) $M_2Si_5N_8:Eu^{2+}$

(3) $M_2Si_{5-x}Al_xN_{8-x}O_x:Eu^{2+}$

(4) $MAl_{1+y}Si_{4-y}N_{7-y}O_y:Eu^{2+}$

where M denotes alkaline earth metal (at least one element selected from Mg, Ca, Sr, and Ba), x satisfies $0 < x < 2$ or 2, and y satisfies 0, $0 < y < 1$ or 1.

[0075] Since the nitride phosphors activated with Eu^{2+} can be used as the red phosphor 9 that emits light with a high degree of efficiency by near-violet - violet light excitation or blue light excitation, both the first solid light emitting element 2a and the second solid light emitting element 2b of the solid light emitting elements 2 can be used to emit light for exciting the red phosphor 9.

[0076] On the other hand, examples of the oxide phosphors or oxysulfide phosphors activated with Eu^{3+} include red phosphors expressed by the following chemical formulas.

[0077] (1) $Ln_2O_2S:Eu^{3+}$

(2) $Ln_2O_3:Eu^{3+},Bi^{3+}$

(3) $Ln(P,V)O_4:Eu^{3+}$

(4) $Ln(P,V)O_4:Eu^{3+},Bi^{3+}$

where Ln is at least one element selected from Sc, Y, La, Ce and Gd.

[0078] Since the oxide phosphor or oxysulfide phosphor activated with Eu^{3+} can be used as the red phosphor 9 that emits light with a high degree of efficiency by near-violet - violet light excitation, the second solid light emitting element 2b can be used, for the solid light emitting elements 2, to emit light for exciting the red phosphor 9.

[0079] Examples of combination structures of the first solid light emitting element 2a, the second solid light emitting element 2b and the wavelength conversion layers 5 are as follows. The combination structure of the semiconductor light emitting device of the present invention may be suitably selected from the following combination structures.

[0080] (1) A structure in which the wavelength conversion layers 5 mixed with the green phosphor 8 and the red phosphor 9 are irradiated with primary light emitted by both the first solid light emitting element 2a and the second solid light emitting element 2b (e.g., FIGS. 1 and 2).

(2) A structure in which primary light emitted by the first solid light emitting element 2a is outputted without illuminating the wavelength conversion layers 5, and a wavelength conversion layer 5a mixed with the red phosphor 9 and a wavelength conversion layer 5b mixed with the green phosphor 8 are irradiated with primary light emitted by the second solid light emitting element 2b (e.g., FIG. 3).

(3) A structure in which the wavelength conversion layer 5a mixed with the red phosphor 9 is irradiated with primary light emitted by the first solid light emitting element 2a and the wavelength conversion layer 5b mixed with the green phosphor 8 is irradiated with primary light emitted by the second solid light emitting element 2b (e.g., FIG. 4).

[0081] With the combination structure (1), a semiconductor light emitting device having a simple configuration can be provided. Thus, the production process can be simplified, so that it is possible to provide a semiconductor light emitting device that can be produced at low cost. Further, primary light emitted by both the first solid light emitting element 2a and the second solid light emitting element 2b is diffused by the phosphor particles and its directivity is weakened. Therefore, it is also possible to obtain white light with less unevenness (color separation) in its color.

[0082] With the combination structure (2), it is possible to provide a semiconductor light emitting device with suppressed variations in the properties at the production that outputs light whose color can be adjusted with relative ease.

[0083] Also with the combination structure (3), it is possible to provide a semiconductor light emitting device with suppressed variations in the properties at the production that outputs light whose color tone can be adjusted with relative ease.

[0084] Furthermore, the green phosphor 8 is excited by near-violet - violet light having a relatively small wavelength emitted by the second solid light emitting element 2b and the red phosphor 9 is excited by blue light having a relatively large wavelength emitted by the first solid light emitting element 2a. Thus, in a device structure using two types of solid light emitting elements that emit light with different wavelength, it is possible to minimize the energy difference between light absorption and light emission of each phosphor.

[0085] The energy difference between light absorption and light emission (equivalent to an energy loss associated with wavelength conversion) of each phosphor involves an increase in the temperature (heat generation) of the wavelength conversion layers 5, which facilitates the temperature extinction of the phosphors and causes a degradation in the performance of a semiconductor light emitting device. Thus, by having the above configuration, since the second solid light emitting element 2b that emits near-violet - violet light having a small wavelength does not excite at least the red phosphor 9 that emits red light having a large wavelength, the energy difference between light absorption and light emission of the red phosphor 9 can be reduced. Consequently, it is possible to achieve a device structure having an advantage in high output.

[0086] In the combination structure (2), as shown in FIG. 3 for example, it is also preferable to dispose a light diffuser 20 (e.g., an inorganic powder, resin particles, etc.) having a light diffusing effect on a light output path for weakening the directivity of light emitted by the first solid light emitting element 2a, when necessary.

[0087] In the semiconductor light emitting device of the present invention, it is preferable that the green phosphor 8 covers at least a main light extraction surface of the second solid light emitting element 2b. In a preferred embodiment, the green phosphor 8 does not absorb blue light emitted by the first solid light emitting element 2a and does not get excited by the blue light. Thus, an output from the green phosphor 8 due to near-violet or violet light emitted by the second solid light emitting element 2b can be controlled with relative ease, and it is possible to provide a semiconductor light emitting device that outputs light whose color tone can be controlled with ease. Here, the term "main light extraction surface" refers to a surface of the solid light emitting elements 2 from which 70 % or more of the entire output light is emitted and the term also will be used with the same meaning in the following.

[0088] In the semiconductor light emitting device of the present invention, as shown in FIG. 4 for example, it is also preferable that the green phosphor 8 covers the main light extraction surface of the second solid light emitting element 2b and the red phosphor 9 covers a main light extraction surface of the first solid light emitting element 2a. Due to this configuration, the output ratio between near-violet - violet light and green light in the output light can be controlled with the second solid light emitting element 2b and the green phosphor 8 and the output ratio between blue light and red light can be controlled with the first solid light emitting element 2a and the red phosphor 9, so that the output ratio between near-violet - violet light and green light and the output ratio between blue light and red light can be controlled separately. Thus, it is possible to provide a semiconductor light emitting device that outputs light whose color tone can be controlled with further ease.

[0089] In the semiconductor light emitting device of the present invention, it is also preferable that the green phosphor 8 and the red phosphor 9 both cover the main light extraction surfaces of both the first solid light emitting element 2a and the second solid light emitting element 2b. Due to this configuration, a structurally simple semiconductor light emitting device can be achieved, so that the production process can be simplified. As a result, it is possible to provide a highly practical semiconductor light emitting device that can be produced at low cost.

[0090] In the semiconductor light emitting device of the present invention, it is preferable that the red phosphor 9 directly covers the main light extraction surfaces of both the first solid light emitting element 2a and the second solid light emitting element 2b, as in the example shown in FIG. 5. Further, it is also preferable that the green phosphor 8 directly covers neither the main light extraction surface of the first solid light emitting element 2a nor the main light extraction surface of the second solid light emitting element 2b, and it is excited by light emitted by the second solid light emitting element 2b that passed through a red phosphor layer containing the red phosphor 9. Due to this configuration, interference between the green phosphor 8 and the red phosphor 9 that occurs when the nitride phosphor activated with Eu^{2+} is used as the red phosphor 9 (mutual interference that occurs due to the red phosphor 9 emitting light by absorbing green light emitted by the green phosphor 8) can be prevented. Consequently, it is possible to provide a semiconductor light emitting device that outputs light whose color tone can be controlled with ease.

[0091] FIG. 1 shows a semiconductor light emitting device of a chip type having a structure in which at least the first solid light emitting element 2a and the second solid light emitting element 2b are disposed in a housing 10 and the wavelength conversion layer 5 containing at least the phosphor 6 is provided in the housing 10.

[0092] In the configuration shown in FIG. 1, the wavelength conversion layer 5 mixed with the green phosphor 8 and the red phosphor 8 is irradiated with primary light emitted by both the first solid light emitting element 2a and the second solid light emitting element 2b. The present invention, however, is not limited to this configuration and it can have any of the structures (1) to (3) described above.

[0093] Each of FIGS. 2 to 4 shows a semiconductor light emitting device having a structure in which at least the first solid light emitting element 2a and the second solid light emitting element 2b are electrically flip-chip mounted on the substrate 1 and one (FIG. 3) or both (FIGS. 2 and 4) of the solid light emitting elements 2 are sealed with resin phosphor films containing at least the phosphor 6 to be the wavelength conversion layers 5.

[0094] For example, in FIG. 2, the wavelength conversion layers 5 mixed with the green phosphor 8 and the red phosphor 9 are irradiated with primary light emitted by both the first solid light emitting element 2a and the second solid light emitting element 2b.

[0095] For example, in FIG. 3, primary light emitted by the first solid light emitting element 2a is outputted without illuminating the wavelength conversion layers 5, and the wavelength conversion layer 5a mixed with the red phosphor 9 and the wavelength conversion layer 5b mixed with the green phosphor 8 are irradiated with primary light emitted by the second solid light emitting elements 2b.

[0096] For example, in FIG. 4, the wavelength conversion layer 5a mixed with the red phosphor 9 is irradiated with primary light emitted by the first solid light emitting element 2a and the wavelength conversion layer 5b mixed with the green phosphor 8 is irradiated with primary light emitted by the second solid light emitting element 2b.

[0097] Since visibility is small in the configurations shown in FIGS. 2 and 4, the thickness of the wavelength conversion layer 5b covering the second solid light emitting element 2b is made larger than that of the wavelength conversion layer 5a covering the first solid light emitting element 2a for reducing the percentage of light emitted by the second solid light emitting element 2b in the output, the light of which contributes less to the luminance of the output light. Due to this configuration, since most of light emitted by the second solid light emitting element 2b, which contributes less to the luminance of the output light, can be absorbed by the phosphor 6 contained in the wavelength conversion layer 5b and it is converted into the green light component 13 having high visibility (FIGS. 6 and 7), it is possible to achieve high output.

[0098] For achieving high output by absorbing even more light emitted by the second solid light emitting element 2b with the phosphor 6, it is preferable that the light emitted by the second solid light emitting element 2b is absorbed not only by the green phosphor 8 but also by the red phosphor 9.

[0099] Further, in the configuration shown in FIG. 3, the number of the second solid light emitting elements 2b is made larger than that of the first solid light emitting element 2a so that photons forming each of the blue light component 12, the green light component 13, and the red light component 14 are well balanced. Furthermore, the green light component 13 and the red light component 14 are wavelength-converted light of light respectively emitted by the different solid light emitting elements 2, so that the blue light component 12, the green light component 13 and the red light component 14 can be controlled independently, and the color tone can be controlled with further ease.

[0100] The present invention has a structure as described above. By energizing the first solid light emitting element 2a and the second solid light emitting element 2b to emit light having an emission peak in a blue wavelength range of 430 nm to less than 490 nm from the first solid light emitting element 2a and light having an emission peak in a near-violet - violet wavelength range of 360 nm to less than 420 nm from the second solid light emitting element 2b and utilizing the wavelength conversion layers 5 containing at least the phosphor 6, a semiconductor light emitting device that emits the blue light component 12, the green light component 13 and the red light component 14 can be achieved.

[0101] Furthermore, the blue light component 12 is a light component emitted by the first solid light emitting element 2a, the green light component 13 is light emitted by the second solid light emitting element 2b being converted into wavelength-converted light by the green phosphor, and the red light component 14 is light emitted by at least one solid light emitting element selected from the first solid light emitting element 2a and the second solid light emitting element 2b being converted into wavelength-converted light by the red phosphor.

[0102] Consequently, a semiconductor light emitting device including at least the blue light component 12 having a small spectrum half-width, the green light component 13 having a small spectrum half-width, and the red light component 14 that emits highly-efficient white output light can be configured using solid light emitting elements that include light emitting layers of the same material system. Thus, it is possible to provide a semiconductor light emitting device that emits highly-efficient white light suitable for a wider range of color expression.

[0103] As can be seen from FIGS. 6 and 7, with respect to the spectral distribution of the white light emitted by such a semiconductor light emitting device, the percentage of output intensity of at least blue-green of 490 nm and yellow of 575 nm is, in a preferred embodiment, 30 % or less, and in a more preferred embodiment, 20 % or less of the peak of the spectral distribution of the output light.

[0104] As a result, the spectral distribution of the white light becomes such that the light is centered on blue, green and red, and when the light is combined with color filters through which blue, green and red light passes, not only is the percentage of the light components lost due to being absorbed by the color filters reduced and high output can be achieved, but also blue, green and red output light excellent in color purity can be obtained. Thus, a wide ranger of color expression can be achieved.

[0105] Further, in a preferred embodiment, most of near-violet - violet light can be absorbed by the phosphors and its wavelength can be converted by means of increasing the thickness of the resin phosphor film or increasing the concentration of the phosphors in the translucent resin that forms the resin phosphor film. Thus, similarly to blue-green and yellow light components, the percentage of output intensity of the near-violet - violet light component 11 can be reduced to 30 % or less, preferably 20 % or less, and more preferably 10 % or less of the peak of spectral distribution of the output light, and thereby high output can be achieved.

[0106] As the example shown in each of FIGS. 2 to 4 illustrates, with the device configuration in which the wavelength conversion layers 5a and 5b irradiated with light emitted by the first solid light emitting element 2a and/or the second solid light emitting element 2b are spatially separated, the color tone of the output light can be controlled with ease, and this configuration is preferable in terms of reducing the percentage of light emitted by the second solid light emitting element 2b (the source of the near-violet - violet light component 11) in the output, for example.

[0107] As described above, with the semiconductor light emitting device of the present invention, it is possible to achieve a wider range of color expression by clearly separating RGB to increase the color purity of each light component of RGB.

[0108] (Embodiment 2)

Next, embodiments of the backlight source and the backlight source system of the present invention will be described.

[0109] FIG. 8 is a perspective view schematically showing one example of the backlight source of the present invention, and the example illustrates an illumination module 16 including a plurality of light emitting portions 15, each using output light of the semiconductor light emitting device according to Embodiment 1.

[0110] The backlight source of the present invention includes at least one semiconductor light emitting device according to Embodiment 1 whose examples are shown in FIGS. 1 to 5, and utilizes output light emitted by the semiconductor light emitting device according to Embodiment 1 as light emitted by each of the light emitting portions 15.

[0111] Further, FIG. 9 is a schematic view showing one example of the backlight source system of the present invention that uses the semiconductor light emitting devices according to Embodiment 1 whose examples are shown in FIGS. 1 to 5. The backlight source system according to the present invention is typically a light source system configured to emit the above-described white light suitable for a wider range of color expression by adding an illumination circuit system 17 to the backlight source of the present invention shown in FIG. 8.

[0112] The effects and the like obtainable from the backlight source and the backlight source system having the configuration as described above are similar to those obtainable from the semiconductor light emitting device according to Embodiment 1.

[0113] (Embodiment 3)

FIG. 10 is a perspective view schematically showing one example of the display device of the present invention in which the backlight source or the backlight source system according to Embodiment 2 schematically shown in FIGS. 8 and 9 is incorporated. The example illustrates a flat display device including display pixels 18.

[0114] A representative example of the display device is a liquid crystal display panel, and it can be formed by combining at least the backlight source according to Embodiment 2, optical modulators, and color filters.

[0115] The display device of the present invention uses the backlight source or the backlight source system according to Embodiment 2, and a liquid crystal display panel as one example thereof can be used in a wide range of electronic devices, such as a mobile phone, a handy-type camcorder, a compact game machine, and a liquid crystal television.

[0116] Since the backlight source or the backlight source system according to Embodiment 2 uses the semiconductor light emitting device according to Embodiment 1, it is possible to provide a display device including at least the blue light component 12 having a small spectrum half-width, the green light component 13 having a small spectrum half-width and the red light component 14 (FIGS. 6 and 7) that emits highly-efficient RGB light.

[0117] Further, since the first solid light emitting element 2a and the second solid light emitting element 2b can include light emitting layers of the same material system, the above-described color balance can be maintained with relative ease and also there is a less necessity for complicating driver circuits.

[0118] Due to a synergy between these effects, it is possible to provide a highly practical display device, in particular, a liquid crystal display panel having both a wider range of color expression and high luminance.

[0119] Since such a liquid crystal display panel has good visibility even in the outdoors where outside light is strong, it is suitable for being applied to a variety of electronic devices usable in the outdoors.

[0120] (Embodiment 4)

FIG. 11 is a schematic view showing one example of a liquid crystal television as a representative example of the electronic device of the present invention, and the television uses the display device according to Embodiment 3.

[0121] A liquid crystal television 19 shown in FIG. 11 is a liquid crystal television with which broadcasts can be enjoyed in both video and audio by adding a broadcast receiver, an audio system, and the like to the display device (liquid crystal display panel) of the present invention shown in FIG. 10.

[0122] Since the liquid crystal television according to Embodiment 4 is assembled using the liquid crystal display panel having both a wide ranger of color expression and high luminance, it is a television device having excellent image display performance. Further, since the liquid crystal display panel has both a wider range of color expression and high luminance and also is compatible with outdoor light in nature, a television device with excellent contrast performance can be designed with relative ease. Therefore, a high-contrast liquid crystal television also can be provided.

[0123] Since the display device of the present invention has excellent visibility even in the outdoors where outside light is strong, effects similar to those obtained from the display device can be obtained from the electronic device of the present invention equipped with the liquid crystal display panel. These effects can be exerted remarkably by the electronic device of the present invention equipped with the liquid crystal display panel when it is designed to be useable also in the outdoors.

[0124] The invention may be embodied in other forms without departing from the sprit of essential characteristics thereof. The embodiments disclosed in this application are to be considered in all respects as illustrative and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are intended to be embraced therein.

Industrial Applicability

[0125] As described above, according to the present invention, it is possible to provide a semiconductor light emitting device suitable for a display device, having both a wider range of color expression and high luminance, a backlight source, a backlight source system, a display device, and the like with relative ease. Thus, the present invention has a great practical value.

Reference Signs List

[0126] 1 substrate

2 solid light emitting element
2a first solid light emitting element
2b second solid light emitting element
3 wiring conductor
4 feeding electrode
5, 5a, 5b wavelength conversion layer
6 phosphor
7 translucent resin
8 green phosphor
9 red phosphor
10 housing
11 near-ultraviolet - violet light component
12 blue light component
13 green light component
14 red light component
15 light emitting portion
16 illumination module
17 illumination circuit system
18 display pixel
19 liquid crystal television
20 light diffuser

Claims

[Claim 1] A semiconductor light emitting device that emits:
a blue light component having an emission peak in a wavelength range of 430 nm to less than 490 nm,
a green light component having an emission peak in a wavelength range of 500 nm to less than 550 nm,
a red light component having an emission peak in a wavelength range of 600 nm to less than 660 nm,
wherein the blue light component is a light component emitted by a first solid light emitting element that emits light having an emission peak in a blue wavelength range of 430 nm to less than 490 nm,
the green light component is light emitted by a second solid light emitting element that emits light having an emission peak in a near-ultraviolet - violet wavelength range of 360 nm to less than 420 nm that is converted into wavelength-converted light by a green phosphor,
the red light component is light emitted by at least one solid light emitting element selected from the first solid light emitting element and the second solid light emitting element that is converted into wavelength-converted light by a red phosphor, and
the green phosphor emits green light on the basis of an electronic energy transition of Mn^{2+}.

[Claim 2] The semiconductor light emitting device according to claim 1, wherein the green phosphor is a green phosphor that substantially does not absorb blue light having a wavelength of 450 nm and does not get excited by the blue light.

[Claim 3] The semiconductor light emitting device according to claim 1 or 2, wherein the green phosphor is a phosphor coactivated with a combination of Eu^{2+} and Mn^{2+} or a combination of Ce^{3+} and Mn^{2+}.

[Claim 4] The semiconductor light emitting device according to claim 3, wherein the green phosphor has an excitation peak in a wavelength range of less than 360 nm and does not have an excitation peak in a near-violet - violet wavelength range of 360 nm to less than 420 nm.

[Claim 5] The semiconductor light emitting device according to claim 1, wherein the green phosphor is an alkaline earth metal aluminate green phosphor coactivated with Eu^{2+} - Mn^{2+}.

[Claim 6] The semiconductor light emitting device according to claim 5, wherein the alkaline earth metal aluminate green phosphor coactivated with Eu^{2+}

- Mn^{2+} is expressed by a composition formula of $BaMgAl_{10}O_{17}:Eu^{2+},Mn^{2+}$.

[Claim 7] The semiconductor light emitting device according to claim 1, wherein the green phosphor is a rare earth aluminate green phosphor coactivated with Ce^{3+} - Mn^{2+}.

[Claim 8] The semiconductor light emitting device according to claim 7, wherein the rare earth aluminate green phosphor coactivated with Ce^{3+} - Mn^{2+} is expressed by a composition formula of $CeMgAl_{11}O_{19}:Mn^{2+}$ or $Ce(Mg,Zn)Al_{11}O_{19}:Mn^{2+}$.

[Claim 9] The semiconductor light emitting device according to claim 1, wherein a light emitting layer of the first solid light emitting element and a light emitting layer of the second solid light emitting element both are made of a composition containing Ga and N.

[Claim 10] The semiconductor light emitting device according to claim 1, wherein the red phosphor is a nitride phosphor or an oxynitride phosphor activated with Eu^{2+}.

[Claim 11] The semiconductor light emitting device according to claim 1, wherein the red phosphor is an oxide phosphor or an oxysulfide phosphor activated with Eu^{3+}.

[Claim 12] The semiconductor light emitting device according to claim 1, wherein the green phosphor covers at least a main light extraction surface of the second solid light emitting element.

[Claim 13] The semiconductor light emitting device according to claim 1, wherein the green phosphor covers a main light extraction surface of the second solid light emitting element and the red phosphor covers a main light extraction surface of the first solid light emitting element.

[Claim 14] The semiconductor light emitting device according to claim 1, wherein the green phosphor and the red phosphor both cover main light extraction surfaces of both the first solid light emitting element and the second solid light emitting element.

[Claim 15] The semiconductor light emitting device according to claim 1, wherein the red phosphor covers main light extraction surfaces of both the first solid light emitting element and the second solid light emitting element,

the green phosphor covers neither the main light extraction surface of the first solid light emitting element nor the main light extraction surface of the second solid light emitting element, and the green phosphor is excited by light emitted by the second solid light emitting element that passed through a red phosphor layer containing the red phosphor.

[Claim 16] A backlight source comprising the semiconductor light emitting device according to claim 1.

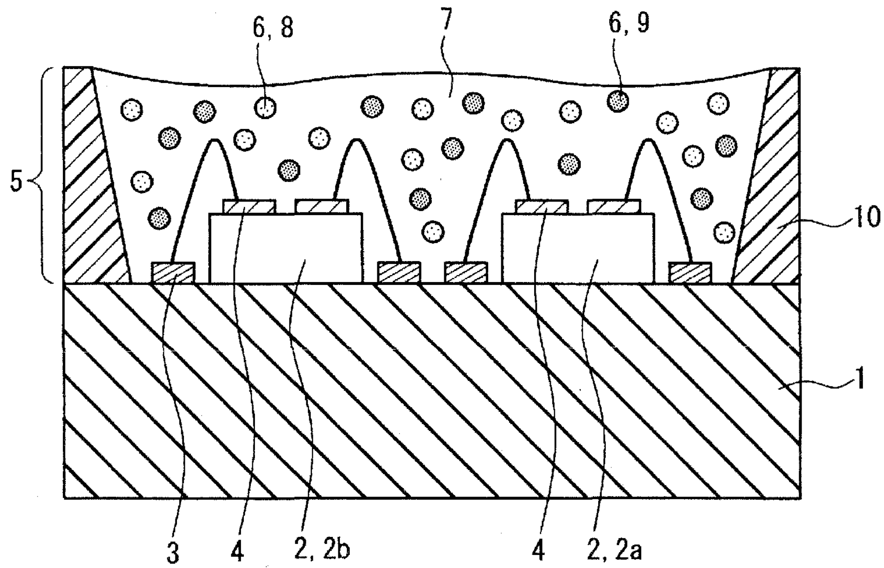
[Claim 17] A backlight source system comprising the semiconductor light emitting device according to claim 1.

[Claim 18] A display device comprising the backlight source according to claim 16 or the backlight source system according to claim 17.

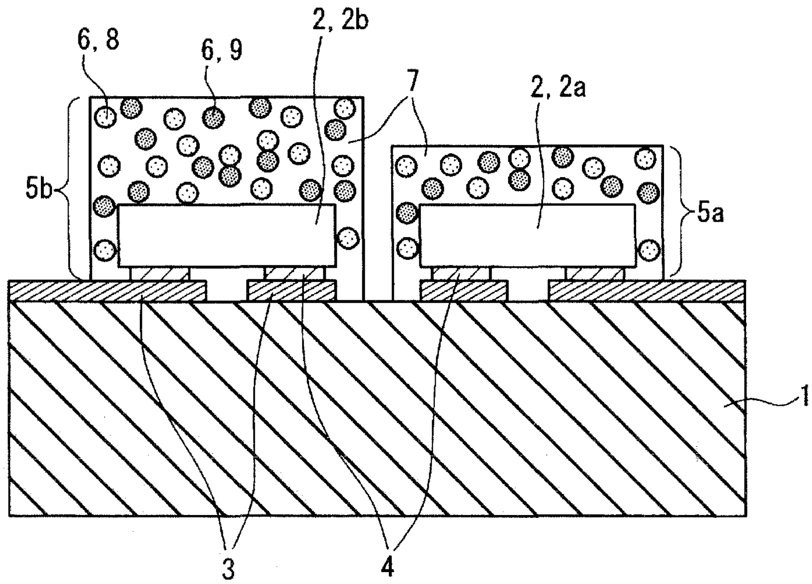
[Claim 19] An electronic device comprising the display device according to claim 18.

[Claim 20] The electronic device according to claim 19, wherein the display device is a liquid crystal display panel.

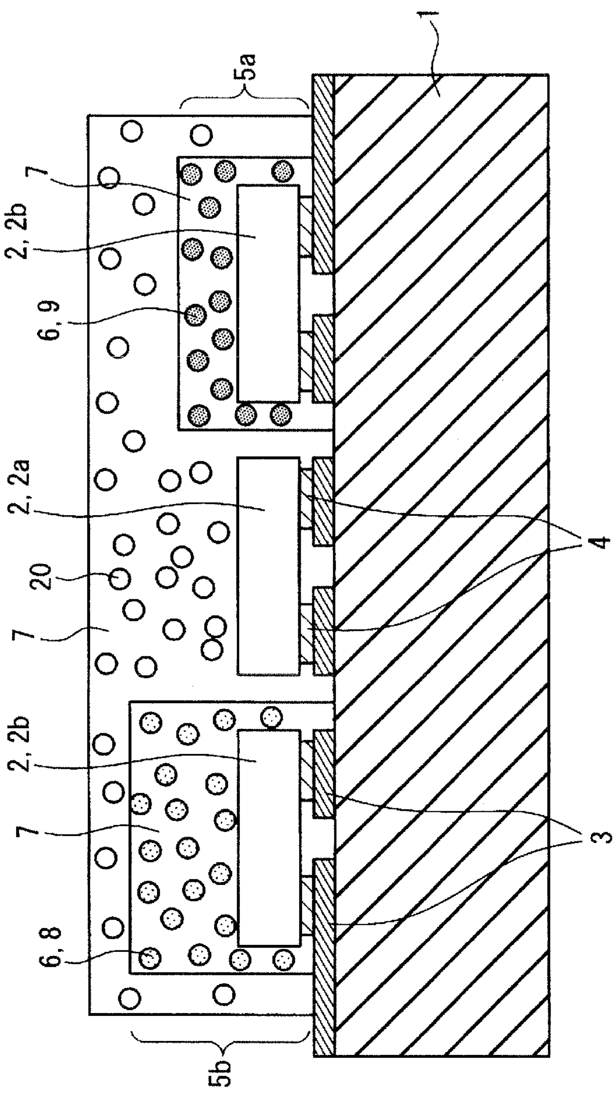
[Fig. 1]



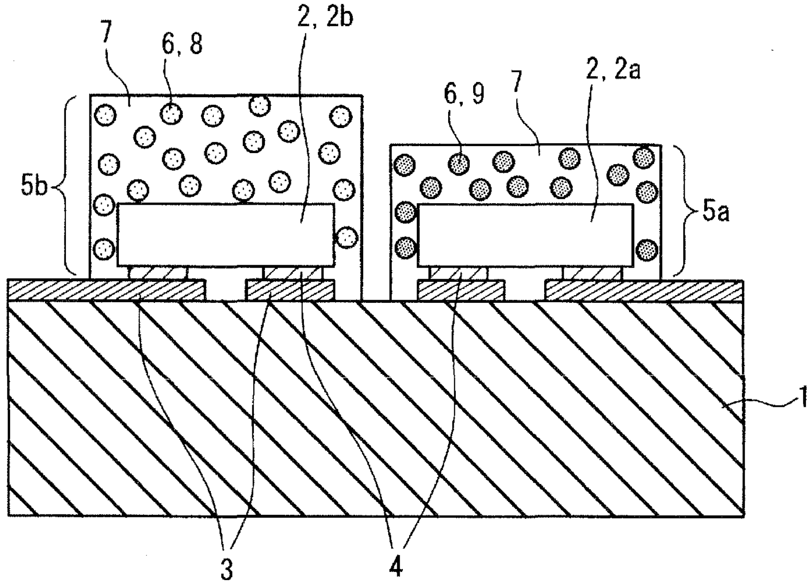
[Fig. 2]



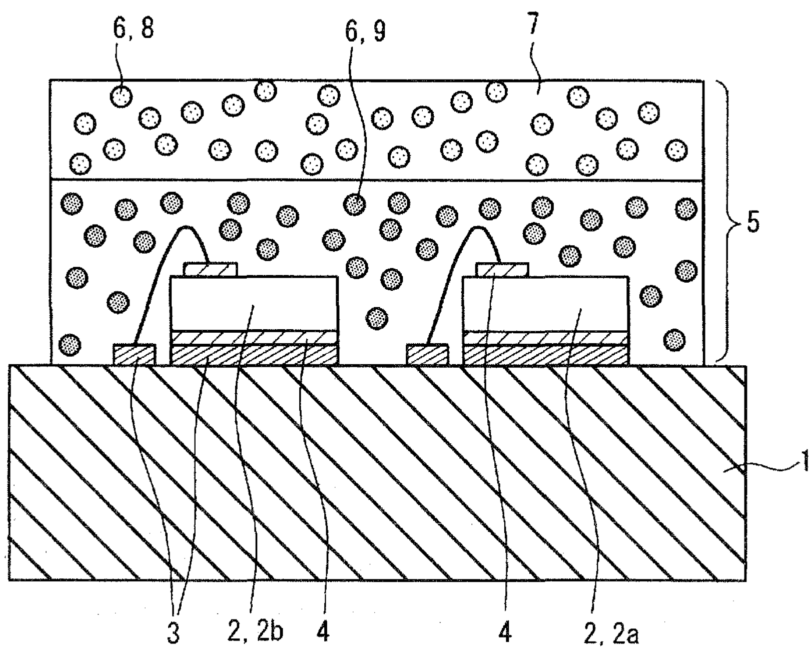
[Fig. 3]



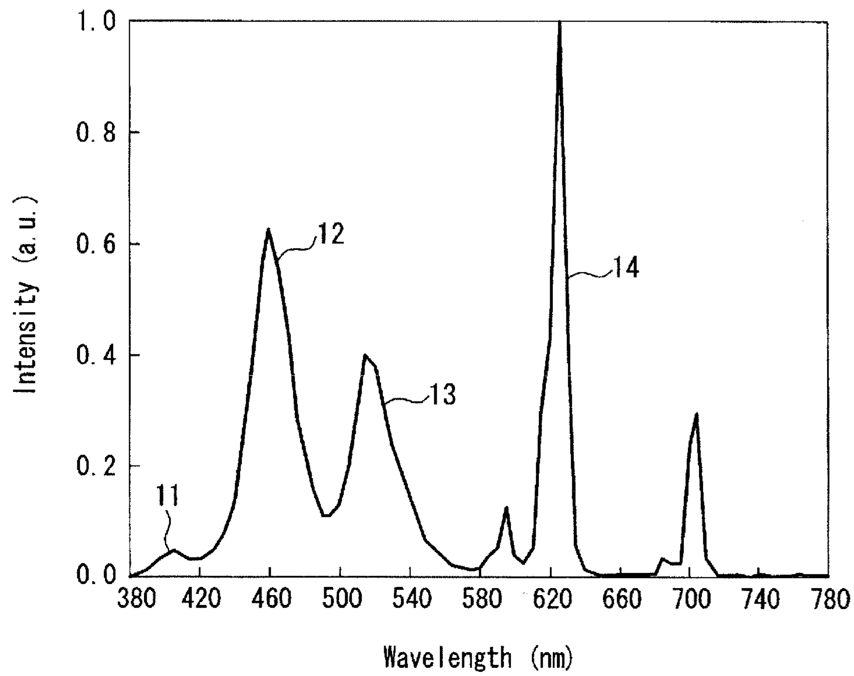
[Fig. 4]



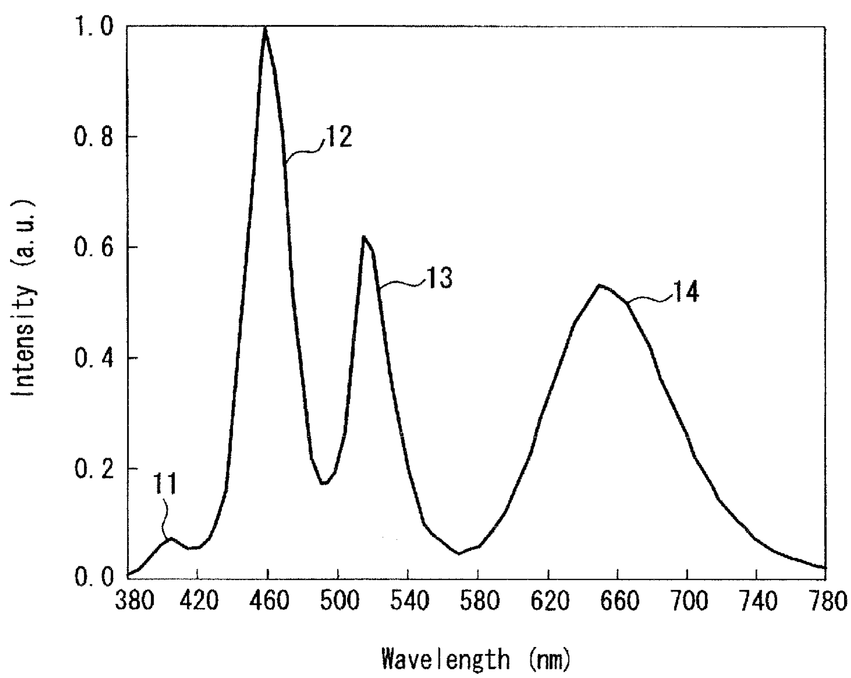
[Fig. 5]



[Fig. 6]


1.0
0.8
0.6
0.4
0.2
0.0
Intensity (a.u.)
380 420 460 500 540 580 620 660 700 740 780
Wavelength (nm)
11
12
13
14

[Fig. 7]


1.0
0.8
0.6
0.4
0.2
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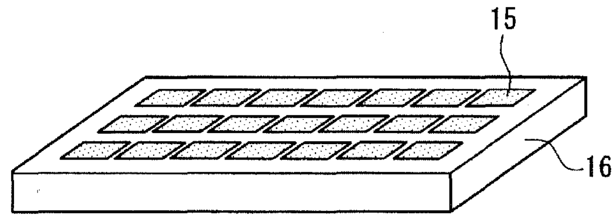
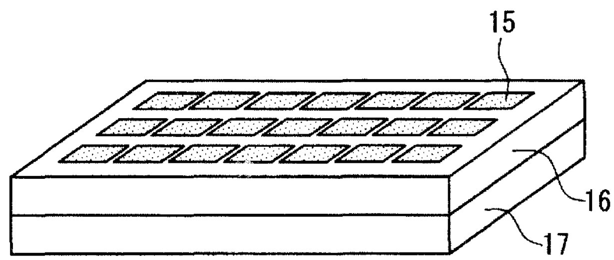
Intensity (a.u.)
380 420 460 500 540 580 620 660 700 740 780
Wavelength (nm)
11
12
13
14

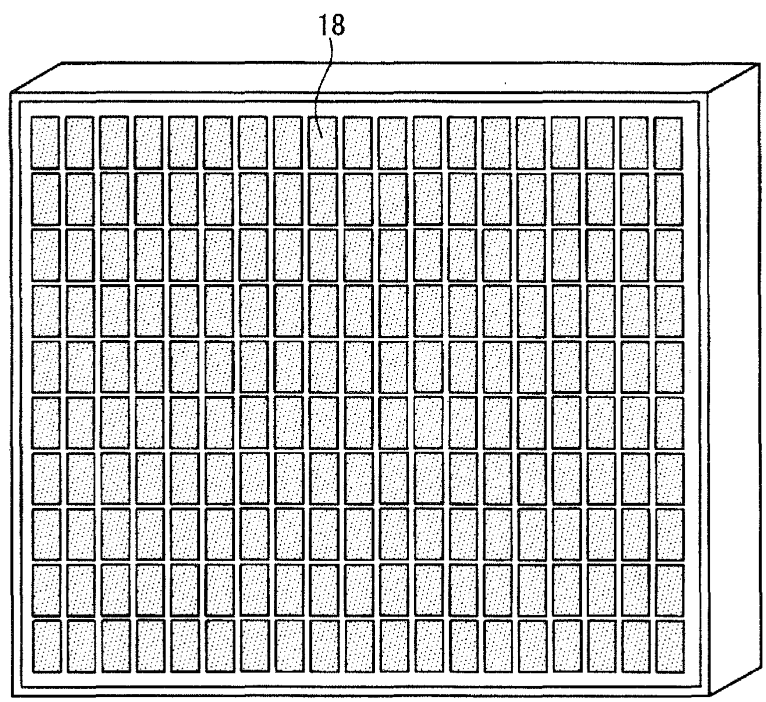
[Fig. 8]



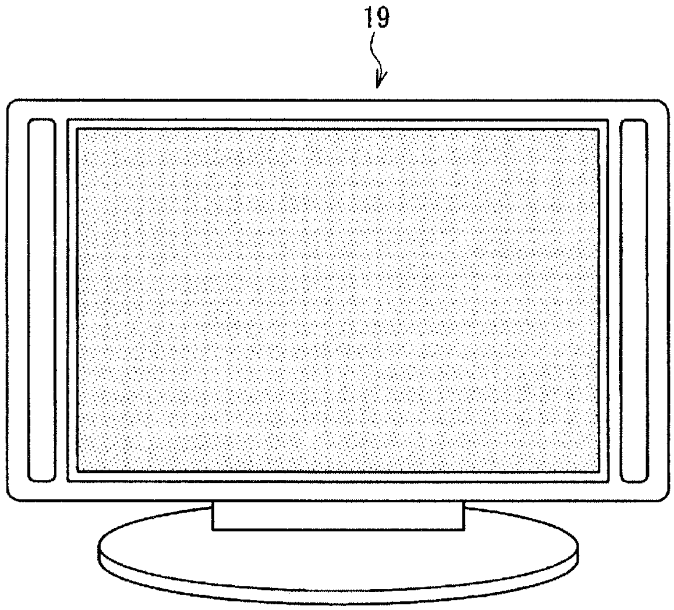
[Fig. 9]



[Fig. 10]



[Fig. 11]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2009/003911

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L25/075 H01L33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2004/207313 A1 (OMOTO MASATOSHI [JP] ET AL) 21 October 2004 (2004-10-21) paragraph [0035] - paragraph [0048]; figures 4A, 4B	1-6,9, 12-20 7-8, 10-11
X Y	DE 102 33 050 A1 (OSRAM OPTO SEMICONDUCTORS GMBH [DE]) 5 February 2004 (2004-02-05) paragraph [0007] - paragraph [0015]; figure 1	1-6,9, 11-20 7-8,10
X A	EP 1 930 393 A1 (DOWA MINING CO [JP]) 11 June 2008 (2008-06-11) paragraph [0150] - paragraph [0164]	1 2-20
X A	JP 2006 128456 A (TOYODA GOSEI KK) 18 May 2006 (2006-05-18) abstract; figure 1	1 2-20

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search: 16 December 2009

Date of mailing of the international search report: 13/01/2010

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2

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2009/003911

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2004/023063 A1 (MUKAI KENJI [JP] ET AL) 5 February 2004 (2004-02-05)	7-8
A	paragraph [0071] - paragraph [0081]	1-6,9-20

Y	EP 1 935 958 A1 (MITSUBISHI CHEM CORP [JP]) 25 June 2008 (2008-06-25)	10-11
A	paragraph [0181] - paragraph [0188]	1-9, 12-20

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/JP2009/003911

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004207313 A1	21-10-2004	CN 1542990 A JP 4274843 B2 JP 2004327492 A	03-11-2004 10-06-2009 18-11-2004
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EP 1930393 A1	11-06-2008	WO 2007037059 A1 KR 20080056170 A US 2009267485 A1	05-04-2007 20-06-2008 29-10-2009
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(12) UK Patent Application (19) GB (11) 2 098 002 A

(21) Application No 8212799
(22) Date of filing 4 May 1982
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(32) 4 May 1981
(33) Fed. Rep. of Germany (DE)
(43) Application published
10 Nov 1982
(51) INT CL^3
H01L 23/30 G02B 1/00
5/22 H01L 33/00
(52) Domestic classification
H1K 1EA 5B1 5B4 5C3D
5H2L PG
F4R 203 417 468 53Y 541
CK
G2J FC
(56) Documents cited
GB 1482794
GB 1290521
(58) Field of search
H1K
G2J

(71) Applicants
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(72) Inventors
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(54) **A luminescent semiconductor component**

(57) A luminescent semiconductor component has a casing member 1 of a light transmissive plastics material containing particles 2 which simultaneously determine the light scattering and filtering properties for the light which is emitted by semiconductor body 5 and passes out of the casing member 1.

The casing member is preferably of epoxy resin, and the particles may be of coloured ground filter glass.

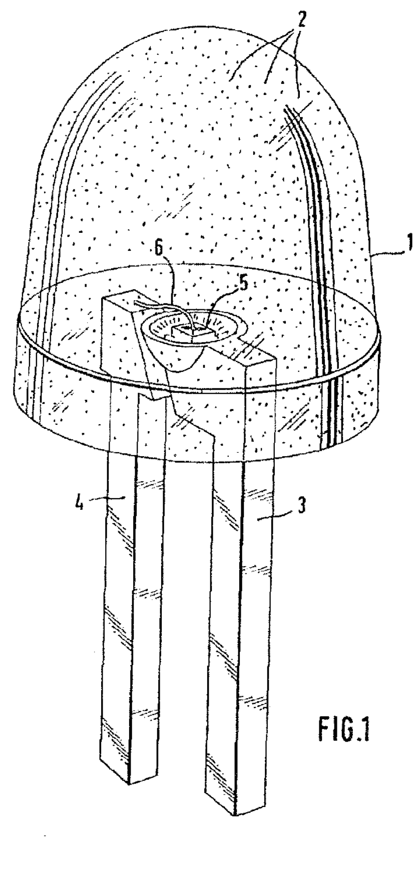

FIG.1

GB 2 098 002 A

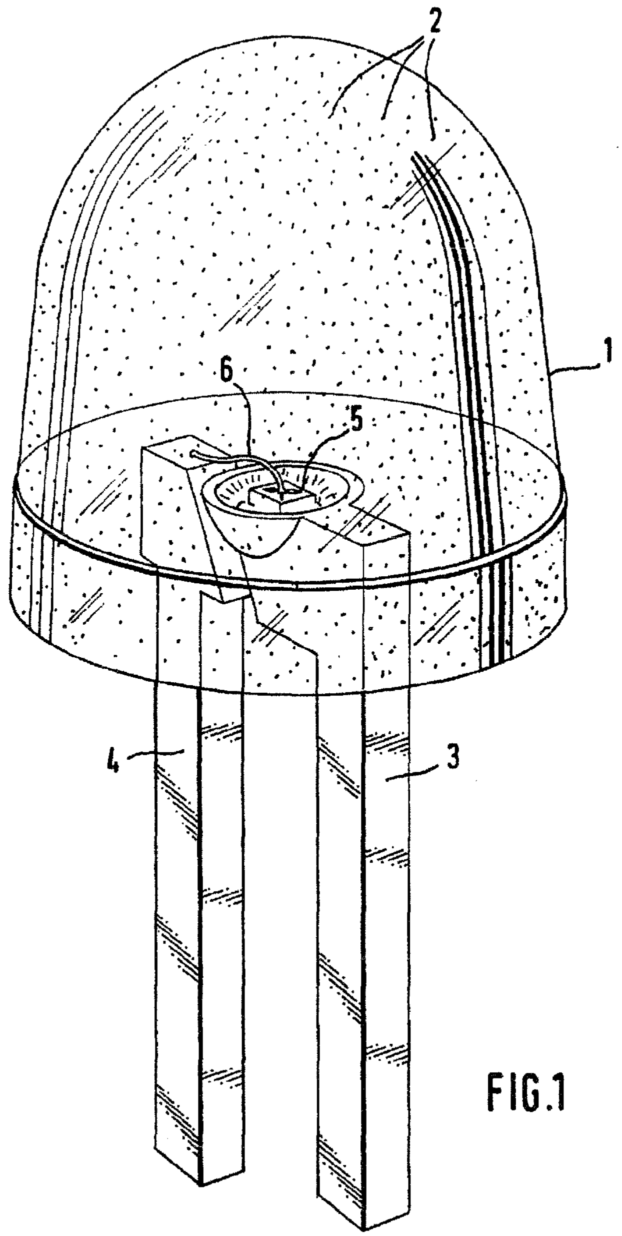

FIG.1

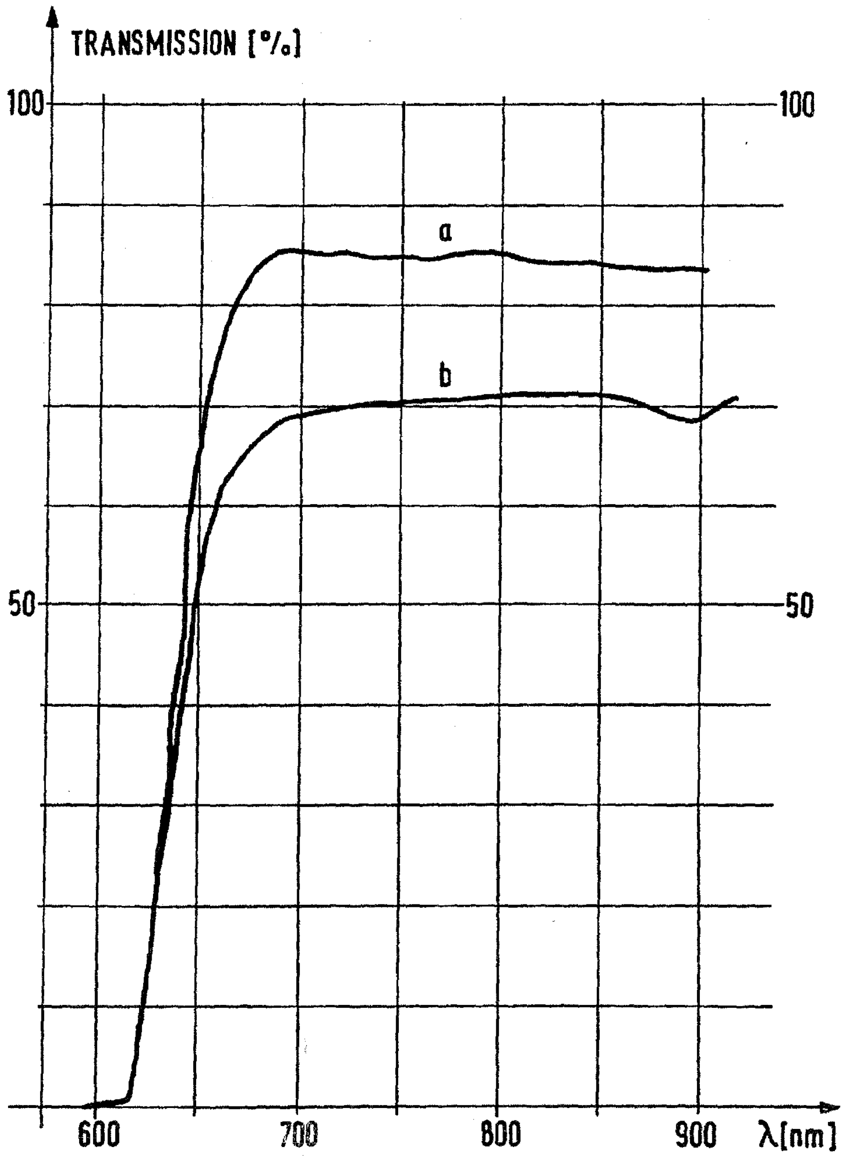

FIG.2

SPECIFICATION

A luminescent semiconductor component

The present invention relates to a luminescent semiconductor component with a casing member containing a semiconductor body and comprising light transmissive plastics material.

Conventionally, the plastics material for the casing of a luminescent semiconductor component is dyed with organic dyes in order to improve the visibility of light emission from the semiconductor component particularly during daylight conditions, and to make it more easily readable. Powdered glass or other solid scattering or dispersing materials, such as titanium oxide, zinc sulphide or $CaCO_3$ may be generally added as the scattering material. For example it is known to add powdered glass from German Patent Specification No. 22 27 322.

It is an object of the present invention to simplify the manufacture of luminescent semiconductor components by implementing certain component properties, previously achieved by various steps, in a single step.

According to a first aspect of the present invention there is provided a luminescent semiconductor component having a casing of light-transmissive plastics material containing particles which simultaneously determine the light scattering and filtering properties of the casing member with respect to light emitted by the component and passing through the casing member.

Thus the previously separate steps of dying the casing member and adding scattering particles, are combined by adding to the casing member particles which have predetermined properties with regard to scattering and filtering light. As a result the process of manufacturing luminescent semiconductor components is simplified and these components can be reproduced with consistent properties in an improved manner.

The plastics of the casing member may comprise a clear epoxy resin to which particles of dyed powdered glass are added. If high transmission is to be achieved the refractive index of the plastics material has to correspond as far as possible with that of the particle material. If, on the other hand, elevated scattering of the light in the casing is desired, then the material of the casing plastics and of the particles added have different refractive indices.

The particles which are added may comprise a ground filter glass in which the grain size is preferably less than 50 μm. Up to approximately 20% by volume of particles which affect the scattering and filtering characteristics are added to the mouldable plastics.

According to a second aspect of the present invention there is provided an edge filter comprising a casing member of light-transmissive plastics material containing particles which simultaneously determine the light-scattering and filtering properties of the casing member.

A preferred embodiment of the present invention will now be described by way of example only, with reference to the accompanying drawings, of which:

Fig. 1 is a perspective view of a luminescent semiconductor component in accordance with the present invention; and

Fig. 2 is a graph showing various light transmission curves related to the component of Fig. 1.

Referring now to Fig. 1 there is shown a single luminescent semiconductor component (e.g a diode) comprising a plastics casing member 1 and two electrical leads 3 and 4 leading out of the plastics casing. Inside the casing member the semiconductor component 5 is electrically connected to the supply lead 3. The second electrode connection of the light emitting semiconductor diode is connected in electrically conductive fashion to a second supply lead 4 via a connecting wire 6.

The casing member may for example comprise epoxy resin with a refractive index of $n_d = 1.5$. However other commercially available mouldable plastics materials can be considered, preferably those which are clear and have a refractive index in the region of between 1.45 and 1.6.

The added particles 2 are located in the plastics member 1 and determine the transmission and/or filtering characteristics and the scattering property of the light emitted by the semiconductor component 5. These particles 2 may for example comprise a ground filter glass obtainable under the name RG630 may be employed. The casing member 1 preferably comprises 2—4% by volume of added particles which have a grain size of approximately 1 μm.

The refractive index of the glass or other added particles can be adapted to the refractive index of the plastics to a greater or lesser extent depending on the desired dispersion effect. The glass used preferably has a refractive index of between 1.3 and 2. If the refractive index of the respective particle material is identical or almost identical to that of the respective plastics, then there is very little scattering dispersion of the radiated light and therefore there is particularly good transmission. The greater the divergence between the refractive indices, the greater the scattering of the light in the plastics member, so that the light source appears diffused to the observer.

In Figure 2 there is shown the path of the transmission curves against wavelength for a red filter glass and for a plastics casing member in which the particles comprising a ground red filter glass are embedded in the plastics member. Curve a) show the path of the transmission over the wavelength for pure red filter glass with the trade name RG630. This glass in an edge filter, since almost all wavelengths under 630 nm are eliminated. At approximately 630 nm the transmission rises sharply from 0 to approximately 85%.

Curve b) shows the transmission curve against wavelength of a plastics member comprising epoxy resin with the trade name OS1600, to which approximately 2% by volume of ground red filter glass of the type RG630 has been added. As is apparent from this curve the transmission is in fact reduced to just over 70% at its maximum; apart from this, however, the same function curve, characteristic of an edge filter, is achieved. The particles added determine both the filtering characteristics and the scattering of the radiated light. Changes in these properties can be achieved by changing the grain size of the particles added, the type of glass and the mixture ratio.

The composition of casing members for luminescent semiconductor components may be used to produce filters for detectors, band filters or edge filters with a steep flank. The shaping of the casing members can be modified to be suitable for light emitting semiconductor components in discrete or integrated form e.g. for displaying digits, letters or other characters.

CLAIMS

1. A luminescent semiconductor component having a casing member of light-transmissive plastics material containing particles which simultaneously determine the light scattering and filtering properties of the casing member with respect to light emitted by the component and passing through the casing member.

2. A component according to claim 1 wherein the plastics material comprises a clear glass epoxy resin.

3. A component according to claim 1 or 2 wherein the particles comprise a coloured glass powder.

4. A component according to any preceding claim wherein the refractive index of the plastics material is substantially the same as that of the material of the particles.

5. A component according to any preceding claim wherein the particles comprise ground filter glass.

6. A component according to any preceding claim wherein the grain size of the particles added is less than 50 μm.

7. A component according to any preceding claim wherein up to 20% by volume of the particles are added to the plastics material.

8. A component according to any preceding claim wherein the casing member serves as an edge filter.

9. A luminescent semiconductor component substantially as herein described with reference to the accompanying drawings.

10. An edge filter comprising a casing member of light-transmissive plastics material containing particles which simultaneously determine the light-scattering and filtering properties of the casing member.

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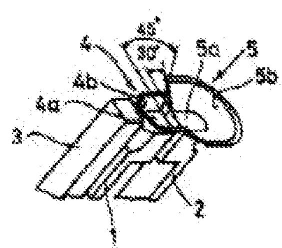
(54) LEAD FRAME FOR LED LAMP, AND LED DISPLAY DEVICE

(57)Abstract:
PURPOSE: To make it possible to balance brightness and a luminous intensity distribution characteristic without varying a current made to flow through LED.
CONSTITUTION: In regard to a lead frame for an LED lamp having a plurality of first frames 1 to 3 at the fore ends of which LED setting parts 4a and 5a on which a plurality of LEDs emitting light with different luminous colors are set and which are connected to a first electrode of each LED are provided respectively and a second frame which is connected to a second electrode of each LED through a bonding wire, the first frames 1 to 3 are formed with the shapes of the LED setting parts 4a and 5a made different from each other so that the light takeout effect in the main light takeout direction of the respective LED setting parts 4a and 5a of the frames be different.



CLAIMS

[Claim(s)]
[Claim 1]Two or more first frames that provided an LED placing part which places two or more LED which emits light with the different luminescent color, respectively, and is connected to the 1st electrode of each of this LED at each tip, respectively, In a leadframe for LED lamps which it has, a second frame connected via a second electrode and a bonding wire of each aforementioned LED each 1st frame of the above, a leadframe for LED lamps having made form of each of this LED placing part differ, and forming so that the optical extraction effect to the main extraction direction of light of that each placing part of LED may be different.
[Claim 2]LED display equipment having a driving device which drives LED which was connected to each 1st frame of the above, and said 2nd frame according to claim 1, and was mounted on each aforementioned LED placing part, respectively according to displayed data.

[Translation done.]

* NOTICES *

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]The present invention relates to the LED display equipment using the leadframe for LED lamps and this which are used for the LED lamp which has two or more LED which emits light with the different luminescent color.
[0002]
[Description of the Prior Art]As a leadframe used for the LED lamp which has two or more LED which emits light with the different luminescent color conventionally, there was a thing as shown, for example in Fig.7.
[0003]Fig.7 is a perspective view showing the conventional leadframe for LED lamps.
[0004]This leadframe comprises the two frames 101,102 for placing two LED, respectively, and the one straight-line frame 103 by which bonding is carried out to two LED. The LED placing part 104,105 with same form is formed in one end of the frame 101,102, respectively, and the LED mounting surfaces 104a and 105a and the light-reflection-walls surfaces 104b and 105b which place LED are formed in them, respectively.
[0005]Fig.8 (a), (b), and (c) is a manufacturing process figure showing the manufacturing method of the above-mentioned leadframe.
[0006]First, the three cylindrical frames 101,102,103 of Fig.8 as shown in (a) are formed.
Then, as each LED placing part 104,105 of the frame 101,102 is shown in Fig.8 (b), V type slots 101a and 102a are formed, respectively.
And if press working of sheet metal of the V type slots 101a and 102a is carried out using the turned-dish-shaped punch of the uniform angle theta and height h as shown in Fig.9, respectively, the leadframe of the form shown by Fig.7 will be completed (Fig.8 (c)).
[0007]
[Problem to be solved by the invention]However, in the leadframe of the above-mentioned composition, Since the form of each LED placing part was isomorphous, the optical extraction effect to the main extraction direction of the light of this LED placing part was not able to operate this optical extraction effect by each LED placing part, when it became equal and the optical power of LED to mount differed.
[0008]Therefore, when the peak optical power of each LED in a LED lamp differed, he changes the current which flows into each LED, and was trying to balance a luminosity. However, there was a problem that the luminosity of each LED could not be balanced on the mounting board to which this current was fixed identically.
[0009]Since luminescence from each different LED differed in each angular distribution, when it molded into a LED lamp, it also generally had the problem that lighting distribution characteristics differed in each color.
[0010]Made in order that the present invention might solve the conventional problem like ****, the purpose is to provide the LED display equipment using the leadframe for LED lamps and this which can balance a luminosity and a lighting distribution characteristic, without changing the current sent through LED.
[0011]

[Means for solving problem]To achieve the above objects, the characteristics of first invention, Provide up the LED placing part which places two or more LED which emits light with the different luminescent color, respectively, and is connected to the 1st electrode of each of this LED at each tip, respectively Two or more first frames, In the leadframe for LED lamps which it has, the second frame connected via the second electrode and bonding wire of each aforementioned LED each 1st frame of the above, It is in having made the form of each of this LED placing part differ, and having formed so that the optical extraction effect to the main extraction direction of the light of that each placing part of LED might be different.
[0012]It is connected to each 1st frame of the above, and the 2nd frame, and there are the characteristics of second invention in having a driving device which drives LED mounted on each aforementioned LED placing part, respectively according to displayed data.
[0013]
[Function]According to the composition like ****, first invention is the punch which changes the volume of the formed parts of each LED placing part of this, and has predetermined form at the time of formation of this LED placing part at the time of processing of the lead base metal used as the formed parts of an LED placing part, for example, By carrying out press working of sheet metal of the formed parts of the LED placing part, the form of each LED placing part of this is changed. Thereby, the optical extraction effect to the main extraction direction of light can be operated now by each LED placing part.
[0014]Since second invention uses the leadframe for LED lamps of first invention, its balance of the luminosity of a LED lamp and a lighting distribution characteristic improves, and it becomes good [the display quality as the whole].
[0015]
[Working example]Hereafter, the working example of the present invention is described based on Drawings. Fig.1 is a perspective view showing the leadframe for LED lamps concerning the 1st working example of the present invention.
[0016]This leadframe is used for the LED lamp (not shown) which has two LED of the different luminescent color, and the one straight-line frame 3 by which bonding is carried out to LED besides the two frames 1 and 2 for placing this 2 piece LED is provided.
[0017]The LED placing parts 4 and 5 are formed in one end of the frames 1 and 2, respectively. The LED mounting surfaces 4a and 5a and the light-reflection-walls surfaces 4b and 5b which place LED are formed in the LED placing parts 4 and 5, respectively. The outside corner of the LED mounting surface 4a by the side of the LED placing part 4 and the light-reflection-walls surface 4b is 45 degrees here, The outside corner of the LED mounting surface 5a by the side of the LED placing part 5 and the light-reflection-walls surface 5b is 30 degrees, and it is set up so that the LED placing part 4 may differ in the angle of the light-reflection-walls surface over an LED mounting surface from the LED placing part 5. The height of the light-reflection-walls surface 4b and the light-reflection-walls surface 5b is the same.
[0018]Fig.2 (a), (b), and (c) is a manufacturing process figure showing the manufacturing method of the leadframe of Fig.1.
[0019]First, a frame base material is processed and the three cylindrical frames 1, 2, and 3 of Fig.2 as shown in (a) are formed. At this time, each point 1a and 2a of the frames 1 and 2 is a portion which becomes the aforementioned LED placing parts 4 and 5 eventually, respectively. Each volume of the points 1a and 2a is determined so that thickness of every place, such as each LED mounting surfaces 4a and 5a in these LED placing parts 4 and 5 and the light-reflection-walls surfaces 4b and 5b, may become equal.

[0020]Then, as each LED placing parts 4 and 5 of the frames 1 and 2 are shown in Fig.2 (b), V type slot 1b and 2b are formed, respectively. And the turned-dish-shaped punch which has the inclined plane 11 with an angle of 45 degrees and the inclined plane 12 with an angle of 30 degrees as shown in Fig.3 is used, As the inclined plane 11 side hits V type slot 1b of the LED placing part 4 and the inclined plane 12 side hits V type slot 2b of the LED placing part 5, respectively, press working of sheet metal of V type slot 1b and the 2b is carried out, respectively. As a result, the leadframe of the form shown by Fig.1 is completed (Fig.2 (c)).

[0021]Thus, the manufactured leadframe is used and a LED lamp is produced as follows.
[0022]First, it places one LED of a pellet type at a time, respectively on the LED mounting surfaces 4a and 5a of the frames 1 and 2. At this time, the upper part of LED becomes a p type electrode, that lower part becomes a n type electrode, and the main extraction direction of light turns into an upper direction of LED. Then, n electrode of Shimobe of each of this LED is made to fix to the frames 1 and 2 with silver paste etc.
[0023]And wire bonding of the p type electrode and the straight-line frame 3 of this LED is carried out with a gold wire etc. Then, the aforementioned frames 1, 2, and 3 in the state where wire bonding was carried out to the predetermined position in a lens-like mold are fixed, and transparent epoxy system resin is injected, burned and hardened in this mold. Then, if a mold is removed, the LED lamp which has two LED of the different luminescent color will be completed.
[0024]When the outside corner mounts red LED of a GaAlAs system on the LED placing part 5 which is 30 degrees, for example according to this example, it is set to 240mcd by 10 mA of force current of LED, and when the outside corner mounts on the LED placing part 4 which is 45 degrees, it is set to 300mcd by 10 mA of the same force current. That is, when it mounts on the LED placing part 5, peak optical power can be suppressed about 20% rather than the case where it mounts on the LED placing part 4.
[0025]Therefore, when the optical power of two LED mounted, for example differs, even if it does not change the force current over each LED, The luminosity of two LED can be balanced by changing the angle of the LED mounting surface and light-reflection-walls surface in the LED placing part of a leadframe in accordance with the optical power of LED.
[0026]When green LED of a GaP system and red LED of a GaAlAs system are mounted on each conventional LED mounting surface 104a and 105a shown in Fig.7, respectively, The latter was set to 5:4 to a peak optical power ratio (red : green) being set to 5:3 as for the former by the case where it mounts on each LED mounting surface 4 and 5 of the Fig.1 of this example, respectively. In this example, the luminosity of LED of the different luminescent color can be balanced so that clearly also from this experiment.
[0027]In this example, when the lighting distribution characteristics of the LED lamp of each color differ, a difference of a lighting distribution characteristic can be reduced like the above.
[0028]Fig.4 is a perspective view showing the leadframe for LED lamps concerning the 2nd working example of the present invention.
[0029]Although the angle of the light-reflection-walls surface over an LED mounting surface was set up in the leadframe of the 1st working example of the above to differ by each LED placing part, the height of a light-reflection-walls surface is set up in this example to differ by each LED placing part.
[0030]This leadframe comprises the two frames 21 and 22 for placing two LED, and the one straight-line frame 23 by which bonding is carried out to LED. The LED placing parts 24 and 25 are formed in one end of the frames 21 and 22, respectively, and the LED mounting surfaces 24a and 25a and the light-reflection-walls surfaces 24b and 25b which place LED are formed in the LED placing parts 24 and 25, respectively.
[0031]Although the angle of the light-reflection-walls surface over an LED mounting surface is the same at the LED placing part 4 and the LED placing part 5, like 3.0 mm and 6.5 mm, the height of the light-reflection-walls surfaces 24b and 25b differs, and is set up, respectively, for example.
[0032]The manufacturing method of such a leadframe only differs in the punch to be used, and is the same as that of the 1st working example of the above.
[0033]The structure of the punch used for this example is shown in Fig.5. That is, the punch of this example serves as turned dish shape which has the 3.0-mm-high portion 31 and the 6.5-mm-high portion 32.
[0034]When green LED of a GaP system is mounted on the LED placing part 25 which has a 6.5-mm-high light-reflection-walls surface, for example according to this example, It is set to 210mcd by 20 mA of force current of LED, and when it mounts on the LED placing part 24 which has a 3.0-mm-high light-reflection-walls surface, it is set to 190mcd by 20 mA of the same force current. That is, when it mounts on the LED placing part 25, peak optical power can be

improved about 10% rather than the case where it mounts on the LED placing part 24.
[0035]Therefore, by changing the height of the light-reflection-walls surface of the LED placing part of a leadframe in accordance with the optical power of LED, even if it does not change the force current over each LED, when the optical power of two LED differs, The luminosity of two LED can be balanced like the 1st working example of the above.
[0036]When red LED of a GaAlAs system and green LED of a GaP system are mounted on each conventional LED mounting surface 104a and 105a shown in Fig.7, respectively, The latter was set to 5:3.5 to a peak optical power ratio (red : green) being set to 5:3 as for the former by the case where it mounts on each LED mounting surface 24 and 25 of the Fig.4 of this example, respectively. The luminosity of LED of the luminescent color from which this example as well as the 1st working example of the above differs can be balanced so that clearly also from this experiment.
[0037]In this example, when the lighting distribution characteristics of the LED lamp of each color differ, a difference of a lighting distribution characteristic as well as the 1st working example of the above can be reduced.
[0038]Fig.6 is a schematic block diagram of the LED display equipment concerning the 3rd working example of the present invention.
[0039]LED lamp groups by which LED display equipment was manufactured using the leadframe of the 1st or 2nd working example of the above is provided with the display part 41 arranged by dot form and the driving device 42 which is connected to this leadframe and drives LED lamp groups of this display part 41 according to displayed data.
[0040]Thus, the LED display equipment which uses the LED lamp manufactured using the leadframe of the present invention is excellent in the balance of the luminosity of a LED lamp, and a lighting distribution characteristic, and its display quality as the whole improves.
[0041]
[Effect of the Invention]As described in details above, in first invention, Since the form of each of this LED placing part was made to differ so that the optical extraction effect to the main extraction direction of the light of each LED placing part may be different, Even if it is a case where LED from which luminous efficiency differs respectively is mounted, the optical extraction effect to the main extraction direction of light can be operated by each LED placing part, and it becomes possible to balance a luminosity and a lighting distribution characteristic.
[0042]Since second invention drives LED mounted on each LED placing part of first invention, respectively according to displayed data, it becomes good [the display quality as the whole].

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a perspective view showing the leadframe for LED lamps concerning the 1st working example of the present invention.
[Drawing 2]It is a manufacturing process figure showing the manufacturing method of the leadframe of Fig.1.
[Drawing 3]It is a figure showing the structure of the punch of the 1st working example.
[Drawing 4]It is a perspective view showing the leadframe for LED lamps concerning the 2nd working example of the present invention.
[Drawing 5]It is a figure showing the structure of the punch used for the 2nd working example.
[Drawing 6]It is a schematic block diagram of the LED display equipment concerning the 3rd working example of the present invention.
[Drawing 7]It is a perspective view showing the conventional leadframe for LED lamps.
[Drawing 8]It is a figure showing the manufacturing method of the leadframe of Fig.7.
[Drawing 9]It is a figure showing the structure of punch using for manufacture of the conventional leadframe.
[Explanations of letters or numerals]
1, 2, 3, 21, 22, and 23 Frame
4, 5, 24, 25 LED placing part
4a, 5a, 24a, 25a LED mounting surface
4b, 5b, 24b, and 25b Light-reflection-walls surface
41 Display part
42 Driving device

[Translation done.]

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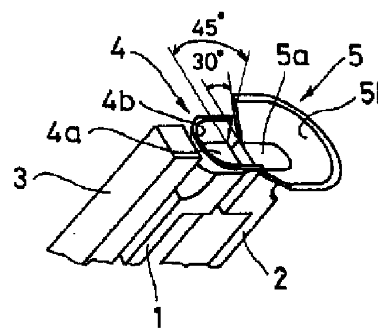
(54)【発明の名称】　ＬＥＤランプ用リードフレーム及びＬＥＤ表示装置

(57)【要約】
【目的】　ＬＥＤに流す電流を変えることなく、明るさ及び配光特性のバランスをとることができるＬＥＤランプ用リードフレーム及びこれを用いたＬＥＤ表示装置を提供することである。
【構成】　異なる発光色で発光する複数のＬＥＤをそれぞれ載置して該各ＬＥＤの第１電極に接続されるＬＥＤ載置部を各先端にそれぞれ設けたて複数の第１のフレームと、前記各ＬＥＤの第２の電極とボンディングワイヤを介して接続される第２のフレームとを有するＬＥＤランプ用リードフレームにおいて、前記各第１のフレームは、その各々のＬＥＤ載置部の光の主取り出し方向への光取り出し効果が相違するように該各ＬＥＤ載置部の形状を異ならしめて形成した。



【特許請求の範囲】

【請求項１】　異なる発光色で発光する複数のＬＥＤをそれぞれ載置して該各ＬＥＤの第１電極に接続されるＬＥＤ載置部を各先端にそれぞれ設けた複数の第１のフレームと、前記各ＬＥＤの第２の電極とボンディングワイヤを介して接続される第２のフレームとを有するＬＥＤランプ用リードフレームにおいて、

前記各第１のフレームは、その各々のＬＥＤ載置部の光の主取り出し方向への光取り出し効果が相違するように該各ＬＥＤ載置部の形状を異ならしめて形成したことを特徴とするＬＥＤランプ用リードフレーム。

【請求項２】　請求項１記載の前記各第１のフレーム及び前記第２フレームに接続され、前記各ＬＥＤ載置部にそれぞれ搭載されたＬＥＤを表示データに従って駆動する駆動装置を有することを特徴とするＬＥＤ表示装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、異なる発光色で発光する複数のＬＥＤを有するＬＥＤランプに使用されるＬＥＤランプ用リードフレーム及びこれを用いたＬＥＤ表示装置に関する。

【０００２】

【従来の技術】従来、異なる発光色で発光する２個以上のＬＥＤを有するＬＥＤランプに使用されるリードフレームとしては、例えば図７に示すようなものがあった。

【０００３】図７は、従来のＬＥＤランプ用リードフレームを示す斜視図である。

【０００４】このリードフレームは、２個のＬＥＤをそれぞれ載置するための２本のフレーム１０１，１０２と、２個のＬＥＤとボンディングされる１本の直線フレーム１０３とで構成されている。さらに、フレーム１０１，１０２の一方の端部には形状が同一のＬＥＤ載置部１０４，１０５がそれぞれ形成され、それらには、ＬＥＤを載置するＬＥＤ載置面１０４ａ，１０５ａと光反射壁面１０４ｂ，１０５ｂとがそれぞれ形成されている。

【０００５】図８（ａ），（ｂ），（ｃ）は、上記のリードフレームの製造方法を示す製造工程図である。

【０００６】まず、図８の（ａ）のような棒状の３本のフレーム１０１，１０２，１０３を形成し、その後、フレーム１０１，１０２の各々のＬＥＤ載置部１０４，１０５について図８（ｂ）に示すようにそれぞれＶ字形溝１０１ａ，１０２ａを形成する。そして、図９に示すような一様の角度θと高さｈの逆皿形のポンチを用い、Ｖ字形溝１０１ａ，１０２ａをそれぞれプレス加工すれば、図７で示した形状のリードフレームが完成する（図８（ｃ））。

【０００７】

【発明が解決しようとする課題】しかしながら、上記構成のリードフレームでは、各々のＬＥＤ載置部の形状が同形であるため、該ＬＥＤ載置部の光の主取り出し方向への光り取り出し効果は等しくなり、搭載するＬＥＤの光出力が異なる場合には、この光り取り出し効果を各々のＬＥＤ載置部によって操作することができなかった。

【０００８】そのため、ＬＥＤランプにおける各々のＬＥＤのピーク光出力が異なる場合には、各ＬＥＤに流れる電流を変えて明るさのバランスをとるようにしていた。ところが、該電流が同一に固定された実装基板上では、各ＬＥＤの明るさのバランスをとることができないという問題があった。

【０００９】また、各々の異なるＬＥＤからの発光は、一般的には各々の角度分布が異なるため、ＬＥＤランプに成形した場合に、各色で配光特性が異なるという問題もあった。

【００１０】本発明は、上述の如き従来の問題点を解決するためになされたもので、その目的は、ＬＥＤに流す電流を変えることなく、明るさ及び配光特性のバランスをとることができるＬＥＤランプ用リードフレーム及びこれを用いたＬＥＤ表示装置を提供することである。

【００１１】

【課題を解決するための手段】上記目的を達成するために、第１の発明の特徴は、異なる発光色で発光する複数のＬＥＤをそれぞれ載置して該各ＬＥＤの第１電極に接続されるＬＥＤ載置部を各先端にそれぞれ設けたて複数の第１のフレームと、前記各ＬＥＤの第２の電極とボンディングワイヤを介して接続される第２のフレームとを有するＬＥＤランプ用リードフレームにおいて、前記各第１のフレームは、その各々のＬＥＤ載置部の光の主取り出し方向への光取り出し効果が相違するように該各ＬＥＤ載置部の形状を異ならしめて形成したことにある。

【００１２】第２の発明の特徴は、前記各第１のフレーム及び第２フレームに接続され、前記各ＬＥＤ載置部にそれぞれ搭載されたＬＥＤを表示データに従って駆動する駆動装置を有することにある。

【００１３】

【作用】上述の如き構成によれば、第１の発明は、例えば、ＬＥＤ載置部の形成部分となるリード母材の加工時に、各々の該ＬＥＤ載置部の形成部分のボリュームを変え、該ＬＥＤ載置部の形成時に所定の形状を有するポンチで、そのＬＥＤ載置部の形成部分をプレス加工することにより、各々の該ＬＥＤ載置部の形状を異ならせる。これにより、各々のＬＥＤ載置部によって光の主取り出し方向への光取り出し効果を操作することができるようになる。

【００１４】第２の発明は、第１の発明のＬＥＤランプ用リードフレームを用いているので、ＬＥＤランプの明るさ及び配光特性のバランスが向上し、全体としての表示品質が良好となる。

【００１５】

【実施例】以下、本発明の実施例を図面に基づいて説明する。図１は、本発明の第１実施例に係るＬＥＤランプ

用リードフレームを示す斜視図である。
【００１６】このリードフレームは、異なる発光色の２個のＬＥＤを有するＬＥＤランプ（図示省略）に使用されるもので、該２個のＬＥＤを載置するための２本のフレーム１，２のほか、ＬＥＤとボンディングされる１本の直線フレーム３が設けられている。
【００１７】フレーム１，２の一方の端部にはＬＥＤ載置部４，５がそれぞれ形成されている。ＬＥＤ載置部４，５には、ＬＥＤを載置するＬＥＤ載置面４ａ，５ａと光反射壁面４ｂ，５ｂとがそれぞれ形成されている。ここで、ＬＥＤ載置部４側のＬＥＤ載置面４ａと光反射壁面４ｂとの外角は４５°であり、ＬＥＤ載置部５側のＬＥＤ載置面５ａと光反射壁面５ｂとの外角は３０°であり、ＬＥＤ載置面に対する光反射壁面の角度がＬＥＤ載置部４とＬＥＤ載置部５とでは異なるように設定されている。なお、光反射壁面４ｂと光反射壁面５ｂとの高さは同一である。
【００１８】図２（ａ），（ｂ），（ｃ）は、図１のリードフレームの製造方法を示す製造工程図である。
【００１９】まず、フレーム母材を加工して図２の（ａ）のような棒状の３本のフレーム１，２，３を形成する。このとき、フレーム１，２の各先端部１ａ，２ａは、それぞれ最終的に前記ＬＥＤ載置部４，５になる部分であり、その先端部１ａ，２ａの各ボリュームは、該ＬＥＤ載置部４，５における各々のＬＥＤ載置面４ａ，５ａ及び光反射壁面４ｂ，５ｂ等の各所の厚みが等しくなるように決定する。
【００２０】その後、フレーム１，２の各々のＬＥＤ載置部４，５について図２（ｂ）に示すようにそれぞれＶ字形溝１ｂ，２ｂを形成する。そして、図３に示すような角度４５°の傾斜面１１及び角度３０°の傾斜面１２を有する逆皿形のポンチを用い、傾斜面１１側がＬＥＤ載置部４のＶ字形溝１ｂに、また、傾斜面１２側がＬＥＤ載置部５のＶ字形溝２ｂにそれぞれ当たるようにして、Ｖ字形溝１ｂ，２ｂをそれぞれプレス加工する。その結果、図１で示した形状のリードフレームが完成する（図２（ｃ））。
【００２１】このようにして製造されたリードフレームを使用して、次のようにＬＥＤランプを作製する。
【００２２】まず、フレーム１，２のＬＥＤ載置面４ａ，５ａの上にペレット状のＬＥＤをそれぞれ１個ずつ載置する。このとき、ＬＥＤの上部がｐ型電極に、その下部がｎ型電極になり、光の主取り出し方向はＬＥＤの上部方向となる。その後、この各ＬＥＤの下部のｎ電極を銀ペーストなどでフレーム１，２に固着させる。
【００２３】そして、該ＬＥＤのｐ型電極と直線フレーム３とを金ワイヤーなどでワイヤーボンディングする。続いて、レンズ状の鋳型の中の所定位置にワイヤーボンディングされた状態の前記フレーム１，２，３を固定し、そして該鋳型の中に透明エポキシ系樹脂を注入して焼き固める。この後、鋳型を取り外せば、異なる発光色の２個のＬＥＤを有するＬＥＤランプが完成する。
【００２４】本実施例によれば、例えばＧａＡｌＡｓ系の赤色ＬＥＤを外角が３０°のＬＥＤ載置部５に搭載した場合は、ＬＥＤの印加電流１０ｍＡで２４０ｍｃｄとなり、外角が４５°のＬＥＤ載置部４に搭載した場合は、同じ印加電流１０ｍＡで３００ｍｃｄとなる。すなわち、ＬＥＤ載置部５に搭載した場合は、ＬＥＤ載置部４に搭載した場合よりもピーク光出力を２０パーセント程度抑えることができる。
【００２５】従って、例えば搭載する２個のＬＥＤの光出力が異なる場合に、各々のＬＥＤに対する印加電流を変えなくとも、リードフレームのＬＥＤ載置部におけるＬＥＤ載置面と光反射壁面との角度をＬＥＤの光出力に合わせて変えることにより、２個のＬＥＤの明るさのバランスをとることができる。
【００２６】また、ＧａＰ系の緑色ＬＥＤとＧａＡｌＡｓ系の赤色ＬＥＤとを、図７に示す従来の各ＬＥＤ載置面１０４ａ，１０５ａにそれぞれ搭載した場合と、本実施例の図１の各ＬＥＤ載置面４，５にそれぞれ搭載した場合とでは、ピーク光出力比（赤色：緑色）が前者は５：３となるのに対し、後者は５：４となった。この実験からも明らかなように、本実施例では異なる発光色のＬＥＤの明るさのバランスをとることができる。
【００２７】さらに、本実施例では、各色のＬＥＤランプの配光特性が異なる場合においても、上記同様に配光特性の相違を軽減することができる。
【００２８】図４は、本発明の第２実施例に係るＬＥＤランプ用リードフレームを示す斜視図である。
【００２９】上記第１実施例のリードフレームでは、ＬＥＤ載置面に対する光反射壁面の角度を各々のＬＥＤ載置部で異なるように設定したが、本実施例では、光反射壁面の高さを各々のＬＥＤ載置部で異なるように設定したものである。
【００３０】このリードフレームは、２個のＬＥＤを載置するための２本のフレーム２１，２２と、ＬＥＤとボンディングされる１本の直線フレーム２３とで構成されている。フレーム２１，２２の一方の端部にはＬＥＤ載置部２４，２５がそれぞれ形成され、そのＬＥＤ載置部２４，２５には、ＬＥＤを載置するＬＥＤ載置面２４ａ，２５ａと光反射壁面２４ｂ，２５ｂとがそれぞれ形成されている。
【００３１】ＬＥＤ載置面に対する光反射壁面の角度はＬＥＤ載置部４とＬＥＤ載置部５とで同一であるが、光反射壁面２４ｂ，２５ｂの高さが例えばそれぞれ３．０ｍｍ及び６．５ｍｍというように異なって設定されている。
【００３２】このようなリードフレームの製造方法は、使用するポンチが異なるだけであって上記第１実施例と同様である。

【００３３】本実施例に用いるポンチの構造を図５に示す。すなわち、本実施例のポンチは、高さ３．０mmの部分３１と高さ６．５mmの部分３２とを有する逆皿形となっている。

【００３４】本実施例によれば、例えばＧａＰ系の緑色ＬＥＤを高さ６．５mmの光反射壁面を有するＬＥＤ載置部２５に搭載した場合は、ＬＥＤの印加電流２０ｍＡで２１０ｍｃｄとなり、高さ３．０mmの光反射壁面を有するＬＥＤ載置部２４に搭載した場合は、同じ印加電流２０mAで１９０ｍｃｄとなる。すなわち、ＬＥＤ載置部２５に搭載した場合は、ＬＥＤ載置部２４に搭載した場合よりもピーク光出力を１０パーセント程度向上させることができる。

【００３５】従って、２個のＬＥＤの光出力が異なる場合に、各々のＬＥＤに対する印加電流を変えなくとも、リードフレームのＬＥＤ載置部の光反射壁面の高さをＬＥＤの光出力に合わせて変えることにより、上記第１実施例と同様に２個のＬＥＤの明るさのバランスをとることができる。

【００３６】また、ＧａＡｌＡｓ系の赤色ＬＥＤとＧａＰ系の緑色ＬＥＤとを、図７に示す従来の各ＬＥＤ載置面１０４ａ，１０５ａにそれぞれ搭載した場合と、本実施例の図４の各ＬＥＤ載置面２４，２５にそれぞれ搭載した場合とでは、ピーク光出力比（赤色：緑色）が前者は５：３となるのに対し、後者は５：３．５となった。この実験からも明らかなように、上記第１実施例と同様に本実施例でも異なる発光色のＬＥＤの明るさのバランスをとることができる。

【００３７】さらに、本実施例では、各色のＬＥＤランプの配光特性が異なる場合においても、上記第１実施例と同様に配光特性の相違を軽減することができる。

【００３８】図６は、本発明の第３実施例に係るＬＥＤ表示装置の概略ブロック図である。

【００３９】ＬＥＤ表示装置は、上記第１または第２実施例のリードフレームを用いて製造されたＬＥＤランプ群が例えばドット状に配列された表示部４１と、該リードフレームに接続されこの表示部４１のＬＥＤランプ群を表示データに従って駆動する駆動装置４２とを備えている。

【００４０】このように、本発明のリードフレームを用＊＊いて製造されたＬＥＤランプを使用するＬＥＤ表示装置は、ＬＥＤランプの明るさ及び配光特性のバランスが優れ、全体としての表示品質が向上する。

【００４１】

【発明の効果】以上詳細に説明したように、第１の発明では、各々のＬＥＤ載置部の光の主取り出し方向への光取り出し効果が相違するように該各ＬＥＤ載置部の形状を異ならしめたので、各々発光効率が異なるＬＥＤを搭載した場合であっても、各々のＬＥＤ載置部によって光の主取り出し方向への光取り出し効果を操作することができ、明るさ及び配光特性のバランスをとることが可能となる。

【００４２】第２の発明は、第１の発明の各ＬＥＤ載置部にそれぞれ搭載されたＬＥＤを表示データに従って駆動するので、全体としての表示品質が良好となる。

【図面の簡単な説明】

【図１】本発明の第１実施例に係るＬＥＤランプ用リードフレームを示す斜視図である。

【図２】図１のリードフレームの製造方法を示す製造工程図である。

【図３】第１実施例のポンチの構造を示す図である。

【図４】本発明の第２実施例に係るＬＥＤランプ用リードフレームを示す斜視図である。

【図５】第２実施例に用いるポンチの構造を示す図である。

【図６】本発明の第３実施例に係るＬＥＤ表示装置の概略ブロック図である。

【図７】従来のＬＥＤランプ用リードフレームを示す斜視図である。

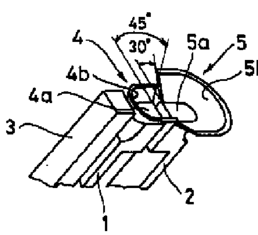
【図８】図７のリードフレームの製造方法を示す図である。

【図９】従来のリードフレームの製造に用いるにポンチの構造を示す図である。

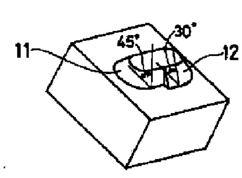
【符号の説明】

１，２，３，２１，２２，２３　フレーム
４，５，２４，２５　ＬＥＤ載置部
４ａ，５ａ，２４ａ，２５ａ　ＬＥＤ載置面
４ｂ，５ｂ，２４ｂ，２５ｂ　光反射壁面
４１　表示部
４２　駆動装置

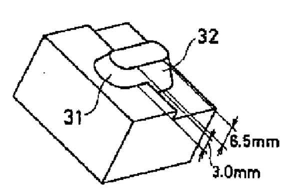
【図１】



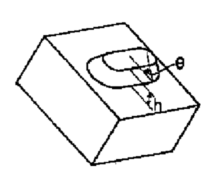
【図３】



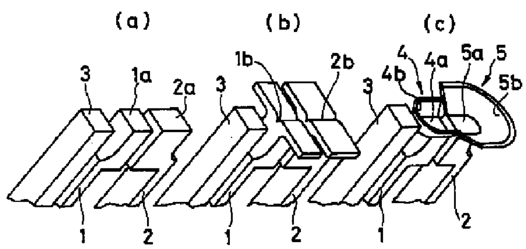
【図５】



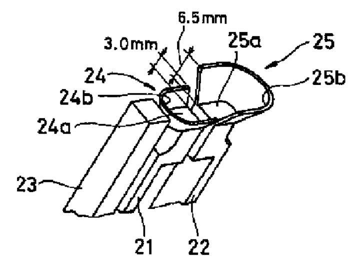
【図９】



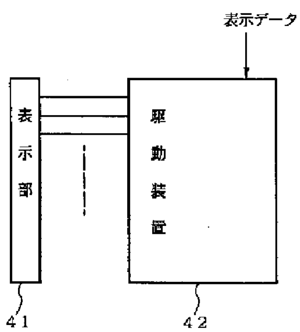
【図2】


(a)
(b)
(c)
3
1a
2a
1
2
1b
2b
4
4a
4b
5a
5
5b

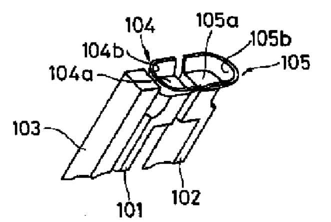
【図4】


6.5mm
3.0mm
25a
25
25b
24
24b
24a
23
21
22

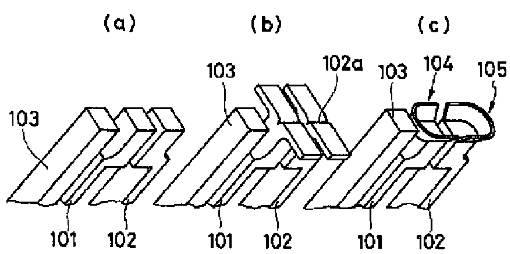
【図6】


表示データ
表示部
駆動装置
41
42

【図7】


104
105a
104b
105b
104a
105
103
101
102

【図8】


(a)
(b)
(c)
103
102a
104
105
101
102

PATENT ABSTRACTS OF JAPAN

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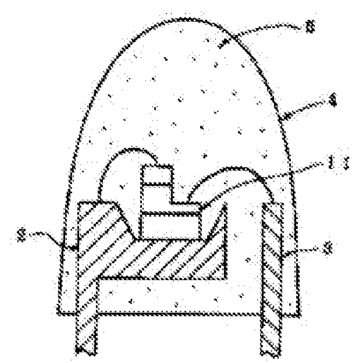
(71)Applicant : NICHIA CHEM IND LTD
(72)Inventor : TADATSU YOSHIAKI
NAKAMURA SHUJI

(54) LIGHT EMITTING DIODE

(57)Abstract:
PURPOSE: To improve the visibility and brightness of a light emitting diode having a light emitting element made of a gallium nitride based compound semiconductor material having its light emitting peaks near 430nm and 370nm.
CONSTITUTION: In a light emitting diode comprising a light emitting elect 11 on a stem and a resin mold 4 surrounding it, the light emitting element 11 is made of a gallium nitride based compound semiconductor specified by a general chemical formula GaxAl1-xN (where 0≤x≤1), and further, a fluorescent dye 5 or a fluorescent pigment, which emits a fluorescent light excited by the light emission of the gallium nitride based compound semiconductor, is added additionally in the resin mold 4.



CLAIMS

[Claim(s)]
[Claim 1]In a light emitting diode which has a light emitting device on a stem and surrounds it by a resin molding, The aforementioned light emitting device consists of a gallium nitride system compound semiconductor denoted by general formula $Ga_X aluminum_{1-X} N$ (however, it is 0<=X<=1), A light emitting diode characterized by coming to add fluorescent dye which is excited by luminescence of the aforementioned gallium nitride system compound semiconductor, and furthermore shows a fluorescence in the aforementioned resin molding, or a fluorescent pigment.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This design starts the light emitting diode (henceforth LED) which surrounds a light emitting device by a resin molding, especially can perform various kinds of luminescence in one kind of light emitting device, and is related with a still higher-intensity wavelength changing light emitting diode.
[0002]
[Description of the Prior Art]Generally, LED has structure as shown in Fig.1. It is a resin molding in which the light emitting device which consists of GaAlAs, GaP, etc., and 2 surround a metal stem for example, 1 was cut by one or less mm square, 3 surrounds a metal post, and 4 surrounds a light emitting device. The rear electrode of the light emitting device 1 is adhered to the metal stem 2 with silver paste etc., and is electrically connected to it, the wire bond of the surface electrode of the light emitting device 1 is carried out on the surface by the gold streak lengthened from the metal post 3 which are other terminals, and the mold of the light emitting device 1 is further carried out by the transparent resin molding 4.
[0003]Usually, although highly transparent resin is chosen highly [are the purpose of emitting luminescence of a light emitting device efficiently into the air and / a refractive index] as for the resin molding 4, An inorganic pigment or an organic color may be mixed as colorant into the resin molding 4 in order to be the purpose of converting the luminescent color of the light emitting device or to correct a color otherwise. For example, the luminescent color can be made white if a red pigment is added in the resin molding of the green emission element which has a semiconductor material of GaP.
[0004]
[Problem to be solved by the invention]However, most technology of adding colorant to a resin molding and converting wavelength to it conventionally is [that the technology which is not put in practical use but carries out color correction with colorant is only used slightly, and]. It is because the luminance of the LED [itself] itself will be deteriorated largely if colorant which is a nonluminescent substance to the extent that wavelength can be converted to a resin molding is added.
[0005]By the way, LED of infrared rays, red, yellow, and green emission is put in practical use as LED now, and blue or ultraviolet LED is not yet put in practical use. The light emitting device of blue and ultraviolet luminescence ZnSe of II-VI group, SiC of IV-group IV, He can proceed research using semiconductor materials, such as III-V fellows' GaN, and it is announced that luminescence whose gallium nitride system compound semiconductor to which a general formula is expressed with $Ga_X aluminum_{1-X}N$ (however, X is 0<=X<=1.) is ordinary temperature and which was comparatively excellent in it also in it is shown these days, and it attracts attention. The first LED to realize pn junction is announced using the gallium nitride system compound semiconductor (applied physics, 60 volumes, No. 2, p163-p166-1991). The luminous wavelength of LED which has a gallium nitride system compound semiconductor of pn junction according to it is mainly near 430 nm, and has a light emission peak also in the ultraviolet area near 370 more nm. The wavelength is the shortest wavelength in the above-mentioned semiconductor material.

However, since the LED has the near luminescent color purple as a luminous wavelength shows, there is a fault that spectral luminous efficacy is bad.
[0006]It is in the present invention having been made in view of such a situation, and the place made into the purpose improving spectral luminous efficacy of LED which has a light emitting device consisting of the gallium nitride system compound semiconductor material which has a light emission peak near 430 nm and near 370 nm, and improving the luminance.
[0007]
[Means for solving problem]In the light emitting diode which the present invention has a light emitting device on a stem, and surrounds it by a resin molding, The aforementioned light emitting device consists of a gallium nitride system compound semiconductor denoted by general formula Ga_Xaluminum$_{1-X}$N (however, it is 0<=X<=1), It is LED characterized by coming to add the fluorescent dye which is excited by luminescence of the aforementioned gallium nitride system compound semiconductor, and furthermore shows a fluorescence in the aforementioned resin molding, or a fluorescent pigment.
[0008]Fig.2 is one working example which shows the structure of LED of the present invention. The blue light element with which, as for 11, a n type and a p type come to laminate GaAlN on silicon on sapphire, and 2 and 3 are the same with Fig.1, and a metal stem, a metal post, and 4 are resin moldings which surround a light emitting device. Since the back surface of the light emitting device 11 is an insulating substrate of sapphire and cannot take out an electrode from a back surface, In order to electrically connect n electrode of a GaAlN layer with the metal stem 2, a GaAlN layer is etched, the surface of a n type layer is exposed, an ohmic electrode is attached, and the technique of electrically connecting by a gold streak is taken. The wire bond of other electrodes is carried out on the surface of the p type layer by the gold streak lengthened from the metal post 3 like Fig.1. The fluorescent dye 5 which emits light in the wavelength which is furthermore excited by the resin molding 4 with the wavelength near 420–440 nm, and has a light emission peak in 480 nm is added.
[0009]
[Effect of the Invention]Generally fluorescent dye and a fluorescent pigment are excited by the light of short wavelength, and emit light in long wavelength light rather than excited wavelengths. Conversely, although there is also a fluorescent pigment which is excited by the light of long wavelength and emits light in the light of short wavelength, energy efficiency is very bad and it does not emit light weakly. As described above, a gallium nitride system compound semiconductor has the light emission peak in the short wavelength side most in the semiconductor material used for LED, and, moreover, has a light emission peak also in the ultraviolet area. Therefore, when it is used as a material of a light emitting device, these fluorescent substances can be most preferably excited by adding fluorescent dye and a fluorescent pigment to the resin molding which surrounds the light emitting device. Therefore, it can convert the light of much wavelength according to the kind of fluorescent dye and fluorescent pigment in saying the color correction of blue LED. The light of short wavelength is changed into long wavelength, and since energy efficiency is good, fluorescent dye and the fluorescent pigment to add can be managed with a minute amount, and are dramatically convenient also from a point of deterioration of luminance.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The schematic cross section showing the structure of the conventional 1LED.
[Drawing 2]The schematic cross section showing the structure of one working example of LED of the present invention.
[Explanations of letters or numerals]
11 ... Light emitting device 2 ... Metal stem
3 ... Metal post 4 --- Resin molding
5 ... Fluorescent dye.

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平5－152609

(43)公開日　平成５年(1993)６月18日

(51)Int.Cl.^{5}	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｈ０１Ｌ　33/00	Ｎ	8934－4M		

審査請求　未請求　請求項の数１(全　３　頁)

(21)出願番号　特願平3－336011

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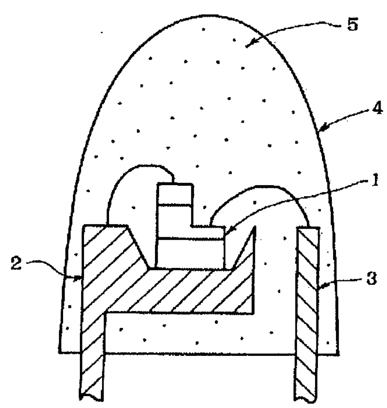
(54)【発明の名称】　発光ダイオード

(57)【要約】
【目的】　発光ピークが４３０ｎｍ付近、および３７０ｎｍ付近にある窒化ガリウム系化合物半導体材料よりなる発光素子を有する発光ダイオードの視感度を良くし、またその輝度を向上させる。
【構成】　ステム上に発光素子を有し、それを樹脂モールドで包囲してなる発光ダイオードにおいて、前記発光素子が、一般式$Ga_xAl_{1-x}N$（但し$0 \leq X \leq 1$である）で表される窒化ガリウム系化合物半導体よりなり、さらに前記樹脂モールド中に、前記窒化ガリウム系化合物半導体の発光により励起されて蛍光を発する蛍光染料、または蛍光顔料が添加されてなる発光ダイオード。



【特許請求の範囲】

【請求項１】　ステム上に発光素子を有し、それを樹脂モールドで包囲してなる発光ダイオードにおいて、前記発光素子が、一般式$Ga_xAl_{1-x}N$（但し$0 \leqq X \leqq 1$である）で表される窒化ガリウム系化合物半導体よりなり、さらに前記樹脂モールド中に、前記窒化ガリウム系化合物半導体の発光により励起されて蛍光を発する蛍光染料、または蛍光顔料が添加されてなることを特徴とする発光ダイオード。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本考案は発光素子を樹脂モールドで包囲してなる発光ダイオード（以下ＬＥＤという）に係り、特に一種類の発光素子で多種類の発光ができ、さらに高輝度な波長変換発光ダイオードに関する。

【０００２】

【従来の技術】一般に、ＬＥＤは図１に示すような構造を有している。１は１mm角以下に切断された例えばＧａＡｌＡｓ、ＧａＰ等よりなる発光素子、２はメタルステム、３はメタルポスト、４は発光素子を包囲する樹脂モールドである。発光素子１の裏面電極はメタルステム２に銀ペースト等で接着され電気的に接続されており、発光素子１の表面電極は他端子であるメタルポスト３から伸ばされた金線によりその表面でワイヤボンドされ、さらに発光素子１は透明な樹脂モールド４でモールドされている。

【０００３】通常、樹脂モールド４は、発光素子の発光を空気中に効率よく放出する目的で、屈折率が高く、かつ透明度の高い樹脂が選択されるが、他に、その発光素子の発光色を変換する目的で、あるいは色を補正する目的で、その樹脂モールド４の中に着色剤として無機顔料、または有機顔料が混入される場合がある。例えば、ＧａＰの半導体材料を有する緑色発光素子の樹脂モールド中に、赤色顔料を添加すれば発光色は白色とすることができる。

【０００４】

【発明が解決しようとする課題】しかしながら、従来、樹脂モールドに着色剤を添加して波長を変換するという技術はほとんど実用化されておらず、着色剤により色補正する技術がわずかに使われているのみである。なぜなら、樹脂モールドに、波長を変換できるほどの非発光物質である着色剤を添加すると、ＬＥＤそのもの自体の輝度が大きく低下してしまうからである。

【０００５】ところで、現在、ＬＥＤとして実用化されているのは、赤外、赤、黄色、緑色発光のＬＥＤであり、青色または紫外のＬＥＤは未だ実用化されていない。青色、紫外発光の発光素子はII-VI族のＺｎＳｅ、IV-IV族のＳｉＣ、III-V族のＧａＮ等の半導体材料を用いて研究が進められ、最近、その中でも一般式が$Ga_xAl_{1-x}N$（但しXは$0 \leqq X \leqq 1$である。）で表される窒化ガリウム系化合物半導体が、常温で、比較的優れた発光を示すことが発表され注目されている。また、窒化ガリウム系化合物半導体を用いて、初めてｐｎ接合を実現したＬＥＤが発表されている（応用物理，６０巻，２号，ｐ１６３～ｐ１６６，１９９１）。それによるとｐｎ接合の窒化ガリウム系化合物半導体を有するＬＥＤの発光波長は、主として４３０ｎm付近にあり、さらに３７０ｎm付近の紫外域にも発光ピークを有している。その波長は上記半導体材料の中で最も短い波長である。しかし、そのＬＥＤは発光波長が示すように紫色に近い発光色を有しているため視感度が悪いという欠点がある。

【０００６】本発明はこのような事情を鑑みなされたもので、その目的とするところは、発光ピークが４３０ｎm付近、および３７０ｎm付近にある窒化ガリウム系化合物半導体材料よりなる発光素子を有するＬＥＤの視感度を良くし、またその輝度を向上させることにある。

【０００７】

【課題を解決するための手段】本発明は、ステム上に発光素子を有し、それを樹脂モールドで包囲してなる発光ダイオードにおいて、前記発光素子が、一般式$Ga_xAl_{1-x}N$（但し$0 \leqq X \leqq 1$である）で表される窒化ガリウム系化合物半導体よりなり、さらに前記樹脂モールド中に、前記窒化ガリウム系化合物半導体の発光により励起されて蛍光を発する蛍光染料、または蛍光顔料が添加されてなることを特徴とするＬＥＤである。

【０００８】図２は本発明のＬＥＤの構造を示す一実施例である。１１はサファイア基板の上にＧａＡｌＮがｎ型およびｐ型に積層されてなる青色発光素子、２および３は図１と同じくメタルステム、メタルポスト、４は発光素子を包囲する樹脂モールドである。発光素子１１の裏面はサファイアの絶縁基板であり裏面から電極を取り出せないため、ＧａＡｌＮ層のｎ電極をメタルステム２と電気的に接続するため、ＧａＡｌＮ層をエッチングしてｎ型層の表面を露出させてオーミック電極を付け、金線によって電気的に接続する手法が取られている。また他の電極は図１と同様にメタルポスト３から伸ばした金線によりｐ型層の表面でワイヤボンドされている。さらに樹脂モールド４には４２０～４４０ｎm付近の波長によって励起されて４８０ｎmに発光ピークを有する波長を発光する蛍光染料５が添加されている。

【０００９】

【発明の効果】蛍光染料、蛍光顔料は、一般に短波長の光によって励起され、励起波長よりも長波長光を発光する。逆に長波長の光によって励起されて短波長の光を発光する蛍光顔料もあるが、それはエネルギー効率が非常に悪く微弱にしか発光しない。前記したように窒化ガリウム系化合物半導体はＬＥＤに使用される半導体材料中で最も短波長側にその発光ピークを有するものであり、しかも紫外域にも発光ピークを有している。そのためそれを発光素子の材料として使用した場合、その発光素子

を包囲する樹脂モールドに蛍光染料、蛍光顔料を添加することにより、最も好適にそれら蛍光物質を励起することができる。したがって青色ＬＥＤの色補正はいうにおよばず、蛍光染料、蛍光顔料の種類によって数々の波長の光を変換することができる。さらに、短波長の光を長波長に変え、エネルギー効率がよい為、添加する蛍光染料、蛍光顔料が微量で済み、輝度の低下の点からも非常に好都合である。

＊【図面の簡単な説明】

【図１】　従来の一ＬＥＤの構造を示す模式断面図。

【図２】　本発明のＬＥＤの一実施例の構造を示す模式断面図。

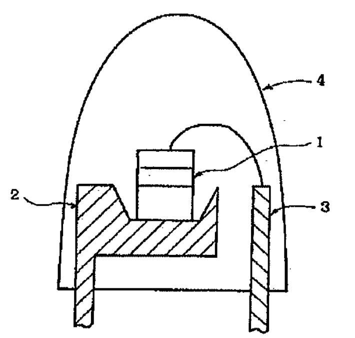
【符号の説明】

１１・・・発光素子　　　２・・・メタルステム

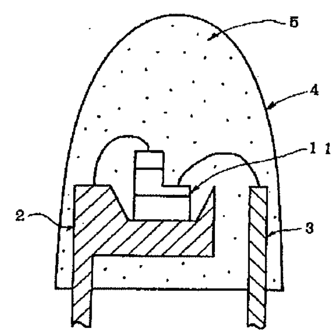
３・・・メタルポスト　　４・・・樹脂モールド

５・・・蛍光染料。

【図１】



【図２】



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FEE TRANSMITTAL

Complete if known	
Application Number	12/559,042 Conf. No.: 7704
Filing Date	September 14, 2009
First Named Inventor	Yoshinori SHIMIZU
Examiner Name	Raj R. Gupta
Art Unit	2829
Practitioner Docket No.	0020-5147PUS7

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 180.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
Application Type	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fees Paid ($)
Utility	390	195	620	310	250	125	
Design	250	125	120	60	160	80	
Plant	250	125	380	190	200	100	
Reissue	390	195	620	310	760	380	
Provisional	250	125	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	62	31
Each independent claim over 3 (including Reissues)	250	125
Multiple dependent claims	460	230

Total Claims ____ -20 or HP = **Extra Claims** ____ x **Fee ($)** ____ = **Fee Paid ($)** ____

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims ____ -3 or HP = **Extra Claims** ____ x **Fee ($)** ____ = **Fee Paid ($)** ____

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims
Fee ($) ____ **Fee Paid ($)** ____

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $320 ($160 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets ____ - 100 = **Extra Sheets** ____ / 50 = **Number of each additional 50 or fraction thereof** ____ (round **up** to a whole number) x **Fee ($)** ____ = **Fee Paid ($)** ____

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $130 fee (no small entity discount) ____

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small entity) ____

Other (e.g., late filing surcharge): Information Disclosure Statement 180.00

SUBMITTED BY			
Signature	Corina Tanasa Reg. NO: 64042	Registration No. (Attorney/Agent) 40439	Telephone 703-205-8000
Name (Print/Type)	D. Richard Anderson for CORINA TANASA		Date MAR 18 2013

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For: LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT		Examiner:	Raj R. Gupta

<u>INFORMATION DISCLOSURE STATEMENT</u>

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. Copies of foreign patent documents, non-patent literature and other information are provided.

☐ b. <u>REFERENCES PREVIOUSLY CITED OR SUBMITTED</u>: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract is provided (as a partial translation) for the following reference(s): JP-7-183581-A and JP-5-152609-A.

A machine-generated translation is provided for the following reference(s): JP-7-183581-A and JP-5-152609-A.

☑ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A copy of the US Office Action issued in Copending US Application No. 12/947,470, dated January 14, 2013, is provided.

A copy of the US Office Action issued in Copending US Application No. 12/689,681, dated February 5, 2013, is provided.

A copy of the European Search Report for counterpart European Application No. 10158422.5, issued on December 19, 2012, is provided.

JP-5-152609-A, cited in the above European Search Report, was previously cited in an Information Disclosure Statement filed on September 14, 2009. The full English machine translation for JP-5-152609-A is now submitted for Examiner's consideration.

A copy of the European Search Report for counterpart European Application No. 10158429.0, issued on December 19, 2012, is provided.

A copy of the European Search Report for counterpart European Application No. 10158437.3, issued on January 3, 2013, is provided.

A copy of the European Search Report for counterpart European Application No. 10158449.8, issued on January 3, 2013, is provided.

A copy of the European Search Report for counterpart European Application No. 10158455.5, issued on January 3, 2013, is provided.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☑ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☐ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance or before an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☑ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance or after an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. PAYMENT OF FEES

☑ The required fee is listed on the attached Fee Transmittal.

☐ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: MAR 18 2013

Respectfully submitted, Reg. No. 64042

By Corina Tanasa

for D. Richard Anderson
Registration No.: 40439 CORINA TANASA
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication(s)
- ☑ Foreign Search Reports – Five (5)
- ☑ Fee
- ☑ Other: US Office Actions – Two (2)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 04/12/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	
ART UNIT	**PAPER NUMBER**
2829	

NOTIFICATION DATE	DELIVERY MODE
04/12/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Applicant-Initiated Interview Summary	**Application No.** 12/559,042	**Applicant(s)** SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	**Art Unit** 2829	

All participants (applicant, applicant's representative, PTO personnel):

(1) RAJ R. GUPTA. (3)_____.

(2) Corina Tanasa 64042. (4)_____.

Date of Interview: 02 April 2013.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: all.

Identification of prior art discussed: none.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

The Applicant initiated the interview to assert that the Final Rejection of 3/12/2013 should have been a Non-Final Rejection. The Examiner upon consideration of the record, particularly the Advisory Action of 6/24/2011 and the Interview Summary of 7/13/2011 where the Examiner indicated that the next Office Action would not be final, agreed to withdraw the finality of the Office Action of 3/12/2013 .

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/RAJ R GUPTA/ Examiner, Art Unit 2829	/HA TRAN T NGUYEN/ Supervisory Patent Examiner, Art Unit 2829

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
– Application Number (Series Code and Serial Number)
– Name of applicant
– Name of examiner
– Date of interview
– Type of interview (telephonic, video-conference, or personal)
– Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
– An indication whether or not an exhibit was shown or a demonstration conducted
– An identification of the specific prior art discussed
– An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
– The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

STATEMENT OF THE SUBSTANCE OF THE INTERVIEW

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Applicants submit the following statement on the substance of the Interview held on April 2, 2013.

On April 2, Applicants' representative called the Examiner to discuss the fact that the Office Action of March 12, 2013 was improperly made final. The finality was premature because the Office Action was issued after a Request for Continued Examination (filed on July 18, 2011) which was submitted to enter claim amendments that include features which the Examiner indicated in the Advisory Action of June 24, 2011 to require new search and consideration.

The Examiner graciously agreed to withdraw the finality of the Office Action of March 12, 2013, as evidenced by the Examiner Interview Summary issued on April 12, 2013. Applicants thank the Examiner for his cooperation.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: May 10, 2013

Respectfully submitted,

By ______________________

D. Richard Anderson
Registration No.: 40,439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

cet

Electronic Acknowledgement Receipt

EFS ID:	15747774
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	David Richard Anderson/Patti Young
Filer Authorized By:	David Richard Anderson
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	10-MAY-2013
Filing Date:	14-SEP-2009
Time Stamp:	16:13:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant summary of interview with examiner	20130510StmtofSubofIntvw.pdf	42596 877c6d0273521c401608cdeae5b7a6f9cb48ca52	no	2

Warnings:

Information:

Total Files Size (in bytes):	42596

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number Number - Kind Code² (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country³ Code Number⁴ Kind Code (if known)⁵	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	1	JP 59-067673 - A	04-17-1984	TOYO COMMUN EQUIP CO LT		☑
						☐
						☐
						☐
						☐
						☐

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

Substitute for form 1449B/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				**Application Number**	12/559,042
				Filing Date	09-14-09
				First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)				Art Unit	2829
				Examiner Name	Raj R. Gupta
Sheet	2	of	2	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	2	Office Action dated April 11, 2013 for U.S. Application No. 12/575,155.	✓
			☐
			☐
			☐
			☐
			☐
			☐
			☐
			☐
			☐

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 59-067673
(43)Date of publication of application : 17.04.1984

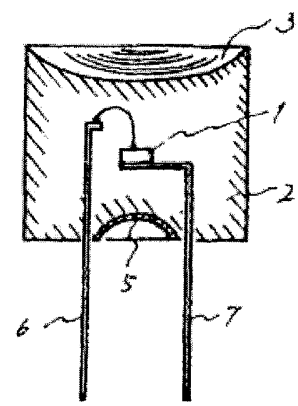
(51)Int.Cl. H01L 33/00

(21)Application number : 57-178631
(22)Date of filing : 12.10.1982

(71)Applicant : TOYO COMMUN EQUIP CO LTD
(72)Inventor : KAZAMA MASAKI

(54) LIGHT EMITTING DIODE FOR SURFACE ILLUMINATION

(57)Abstract:
PURPOSE: To diffuse light uniformly with good efficiency by a method wherein a convex mirror is arranged at the bottom of a resin coat with a built-in light emitting diode, and a light radiating surface at the top of the resin coat is formed into a concave lens.
CONSTITUTION: The bottom of the cylindrical resin coat 2 containing an LED chip 1, immediately under the LED chip 1, is recessed, resulting in the formation of the convex mirror 5 in view from the LED chip 1, and lead members 6 and 7 supporting the LED chip 1 are arranged in the periphery thereof. Besides, the top of the resin coat 2 is recessed and so constructed as to be the concave lens 3. Thus, a part of the light radiated from the LED chip 1 is reflected diffusively on the convex mirror 5, and a part thereof repeats reflection also on the inner wall of the resin coat 2, and is then radiated while further expanding by the top concave lens 3; accordingly a uniform diffused light can be obtained.



等の光拡散面に於いて、その背後に配置した各LEDの輝点が分離して見え輝度の均一な単一発光面とすることが困難であった。

本発明は従来のLEDの上述した欠点を解消すべくなされたものであって、LEDチップを収納する樹脂コートの底面を凸面鏡とすると共に前記樹脂コート頂部の光放出面を凹レンズとし、更に必要ならば前記樹脂コート底部に形成した凸面鏡の底面及び外側壁面に光の高効率反射処理を施し、或は前記樹脂コート頂部の凹レンズをフレネル凹レンズとした面照明用発光ダイオードを提供することを目的とする。

以下、本発明を図面に示す実施例に基づいて詳細に説明する。

第3図は本発明に係るLEDの構造を示す断面図である。

即ち、LEDチップ1を収納する筒状樹脂コート2の底部、前記LEDチップ1直下を凹陥せしめて前記LEDチップ1からみて凸面鏡5を形成しその周辺に前記LEDチップ1を支持するリード部材6及び7を配設する。又前記樹脂コート2の頂部を凹陥せしめ凹レンズ3となるよう構成する。

斯くすることによって前記LEDチップ1を発した光の一部は前記凸面鏡5に於いて拡散的に反射し、更に前記樹脂コート2の内壁に於いてもその一部が反射を繰り返えし、前記頂部の凹レンズ3で一層広がりつつ放出されることになり従来のLEDに比してはるかに均一な拡散光を得ることができる。

しかしながら、これでも前記樹脂コート2側壁を透過或は側壁に吸収される光エネルギも少なくないので更に発光面輝度の向上を必要とする場合には第4図に示す如く前記樹脂コート2の外側壁及び底部外面に例えば銀鏡反応或はアルミニウム蒸着等によって高効率の反射被膜8を形成すればよい。

上記反射被膜8は前記樹脂コート2の成形終了後その底部に形成される凹陥部、即ち前記凸面鏡5に対する被膜形成と同時に行うのが効率的である。

尚、本発明に於いては第5図に示す如く前記樹脂コート2の頂部に形成する凹レンズ3の代りにフレネル凹レンズ9を形成しても同様の効果を奏するものである。

本発明は以上説明した如く構成するのでLEDチップの発する光を効率よくしかも均一に拡散することができるのでこれを単独で使用する場合はもとよりこれを多数集合して大面積表示部を照面する場合、その表示面を均一かつ高輝度に照明する上で著しい効果を発揮する。

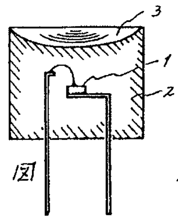
更に複数種の光色を発するLEDを多数集合して白色光を合成し、これによって表示面を照明する場合、各LEDから放出される光の拡散が充分に行なわれる為、むらのない自然光に近い表示面を得る効果をも併せもつものである。

4.図面の簡単な説明

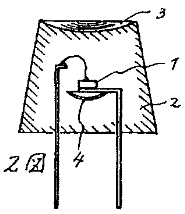
第1図及び第2図は夫々従来の面照明用LEDの異った構造を示す断面図、第3図は本発明に係る面照面用LEDの一実施例の構造を示す断面図、第4図及び第5図は夫々本発明の面照明用LEDの他の実施例を示す断面図である。

1…発光ダイオード，3…凹レンズ，2…樹脂コート，5…凸面鏡，8…反射面，9…フレネル凹レンズ

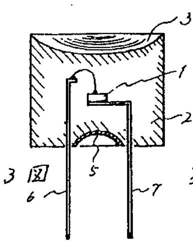
特許出願人　東洋通信機株式会社



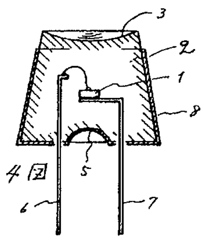
第1図



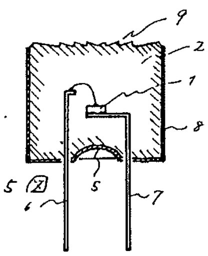
第2図



第3図



第4図



第5図

Electronic Patent Application Fee Transmittal

Application Number:	12559042
Filing Date:	14-Sep-2009
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Filer:	Penny L Caudle/leslie berry
Attorney Docket Number:	0020-5147PUS7

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	15982769
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Penny L Caudle/leslie berry
Filer Authorized By:	Penny L Caudle
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	07-JUN-2013
Filing Date:	14-SEP-2009
Time Stamp:	16:08:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$180
RAM confirmation Number	2942
Deposit Account	022448
Authorized User	ANDERSON, RICHARD D.

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		2013-06-07-IDS-0020-5147PUS7.pdf	453262 2342f4dd811b7251d29a5395a910f009648d851b	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Transmittal Letter	2	7
Information Disclosure Statement (IDS) Form (SB08)	8	9

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Foreign Reference	JP59-067673.pdf	106151 d58b4ce2af11e29cbaec894936e1488aee67f68a	no	3

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Non Patent Literature	US12-575155.pdf	432353 673f3a6a67bcd681be2d03574fb50bdaf24c006d	no	11

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Fee Worksheet (SB06)	fee-info.pdf	30225 cc235dd4f8cbecdb04e77e464b9ac0420b5e1f16	no	2

Warnings:

Information:

Total Files Size (in bytes): 1021991

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/17 (03-13)
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FEE TRANSMITTAL

Complete if known	
Application Number	12/559,042 Conf. No.: 7704
Filing Date	September 14, 2009
First Named Inventor	Yoshinori SHIMIZU
Examiner Name	Raj R. Gupta
Art Unit	2829
Practitioner Docket No.	0020-5147PUS7

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) 180.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ______

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

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FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	U ($)	S ($)	M ($)	U ($)	S ($)	M ($)	U ($)	S ($)	M ($)	Fees Paid ($)
Utility	280	140*	70	600	300	150	720	360	180	
Design	180	90	45	120	60	30	460	230	115	
Plant	180	90	45	380	190	95	580	290	145	
Reissue	280	140	70	600	300	150	2,160	1,080	540	
Provisional	260	130	65	0	0	0	0	0	0	

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	Undiscounted Fee ($)	Small Entity Fee ($)	Micro Entity Fee ($)
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims ______ -20 or HP = **Extra Claims** ______ x **Fee ($)** ______ = **Fee Paid ($)** ______

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims ______ -3 or HP = **Extra Claims** ______ x **Fee ($)** ______ = **Fee Paid ($)** ______

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims **Fee ($)** ______ **Fee Paid ($)** ______

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets ______ - 100 = **Extra Sheets** ______ / 50 = **Number of each additional 50 or fraction thereof** ______ (round **up** to a whole number) x **Fee ($)** ______ = **Fee Paid ($)** ______

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $130 fee (no small or micro entity discount) ______

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity) ______

Other (e.g., late filing surcharge): IDS Fee 180.00

SUBMITTED BY			
Signature	Penny Caudle #46,607	Registration No. (Attorney/Agent) 40439	Telephone 703-205-8000
Name (Print/Type)	D. Richard Anderson		Date June 7, 2013

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of: Yoshinori SHIMIZU et al.			
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

<u>INFORMATION DISCLOSURE STATEMENT</u>

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. Copies of foreign patent documents, non-patent literature and other information are provided.

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date

12/028,062 filed February 8, 2008

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract is provided (as a partial translation) for the following reference(s): JP 59-67673

A machine-generated translation is provided for the following reference(s):

A partial translation is provided for the following reference(s):

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A U.S. Office Acton issued in co-pending Application No. 12/575,155, dated April 11, 2013 is submitted herein.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30**

days prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☐ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance or before an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(c)(1)).

- ☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

  or

- ☐ See the above statement. No fee is required.

☑ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance or after an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. PAYMENT OF FEES

- ☑ The required fee is listed on the attached Fee Transmittal.
- ☐ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: June 7, 2013

Respectfully submitted,

By Penny Caudle #46,607

D. Richard Anderson
Registration No.: 40439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

- ☑ PTO/SB/08
- ☑ Document(s)
- ☐ Foreign Patent Office Communication(s)
- ☐ Foreign Search Report(s)
- ☑ Fee
- ☐ Other:

Docket No.: 0020-5147PUS7
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Yoshinori SHIMIZU et al.

Confirmation No.: 7704

Application No.: 12/559,042

Art Unit: 2829

Filed: September 14, 2009

Examiner: Raj R GUPTA

For: LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT

AMENDMENT UNDER 37 C.F.R. § 1.111

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

In response to the Non-Final Office Action dated March 12, 2013, please amend the above-identified U.S. patent application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 9 of this paper.

wt

AMENDMENTS TO THE CLAIMS

1. (**Currently Amended**) A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount in a recess formed in said mount,

a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein

said [[a]] first region is in the vicinity of at least one of said light emitting chips, and

said [[a]] second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and

a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero,

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and

wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin and metalized ceramic.

2. (**Previously Presented**) The light emitting device according to claim 1, wherein said mount comprises a metalized ceramic.

3. (**Currently Amended**) A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount in a recess formed in said mount,

a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein

said [[a]] first region is in the vicinity of at least one of said light emitting chips, and

said [[a]] second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and

a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero,

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and

a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

4. **(Previously Presented)** The light emitting device according to claim 1, wherein said light emitting chips emit a light having a spectrum with a peak in the range from 420 to 490 nm, said phosphor emits light having a spectrum with a peak in the range from 510 to 600 nm and a tail continuing beyond 700 nm, and said spectrum of the light emitted from said phosphor and said spectrum of the light emitted from said light emitting chips overlap with each other to make a continuous combined spectrum.

5. **(Previously Presented)** The light emitting device according to claim 4, wherein said spectrum of the light emitted from said phosphor has a peak in the range from 530 to 570 nm and a tail continuing beyond 700 nm.

6. (**Previously Presented**) The light emitting device according to claim 4, wherein a color of said combined spectrum is white.

7. (**Previously Presented**) The light emitting device according to claim 1, wherein said phosphor comprises two or more kinds of fluorescent materials.

8. (**Previously Presented**) The light emitting device according to claim 1, wherein said phosphor comprises an yttrium-aluminum-garnet fluorescent material containing Y and Al.

9. (**Previously Presented**) The light emitting device according to claim 1, wherein said phosphor has a crystal structure.

10. (**Previously Presented**) The light emitting device according to claim 1, wherein said phosphor diffuses said light emitted from said light emitting chips.

11. (**Previously Presented**) The light emitting device according to claim 1, wherein said light emitting chips comprise a light emitting layer of single quantum well or multi quantum well structure.

12. (**Previously Presented**) The light emitting device according to claim 1, wherein said light emitting chips comprise InGaN.

13. (**Previously Presented**) The light emitting device according to claim 1, wherein said light emitting chips comprise a sapphire substrate.

14. (**Previously Presented**) The light emitting device according to claim 1, wherein said transparent material is selected from the group consisting of epoxy resin, urea resin, silicone resin and glass.

15. (**Previously Presented**) The light emitting device according to claim 1, wherein said transparent material contains a dispersant.

16. (**Previously Presented**) The light emitting device according to claim 15, wherein said dispersant is selected from the group consisting of barium titanate, titanium oxide, aluminum oxide and silicon dioxide.

17. (**Previously Presented**) The light emitting device according to claim 1, wherein said transparent material contains a coloration agent.

18. (**Previously Presented**) The light emitting device according to claim 1, wherein said mount is plated with silver, copper or gold.

19. (**Previously Presented**) The light emitting device according to claim 3, wherein said mount is plated with silver, copper or gold.

20-21. (**Canceled**)

22. (**Currently Amended**) A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount,

a plurality of inner leads electrically separated from said mount, each inner lead being connected to one of said light emitting chips,

a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein

said [[a]] first region is in the vicinity of at least one of said light emitting chips, and said [[a]] second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and

a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero,

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and

wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin and metalized ceramic.

23. (**Canceled**)

24. (**Currently Amended**) A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount,

a plurality of inner leads electrically separated from said mount, each inner lead being connected to one of said light emitting chips,

a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein

said [[a]] first region is in the vicinity of at least one of said light emitting chips, and

said [[a]] second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, <u>wherein the concentration of said phosphor in said second region in said transparent material is larger than zero,</u>

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and

a thermal conductivity of said mount is not less than 0.01 cal/(s)(cm^2)(°C/cm).

25. **(Canceled)**

26. **(New)** A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount in a recess formed in said mount,

a transparent material directly covering said light emitting chips, said transparent material including

a first region in the vicinity of at least one of said light emitting chips, and

a second region in the vicinity of the surface of said transparent material, and

a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material,

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin and metalized ceramic.

27. (**New**) A light emitting device comprising:

a mount,

a plurality of light emitting chips mounted on said mount,

a plurality of inner leads electrically separated from said mount, each inner lead being connected to one of said light emitting chips,

a transparent material directly covering said light emitting chips, said transparent material including

a first region in the vicinity of at least one of said light emitting chips, and

a second region in the vicinity of the surface of said transparent material, and

a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,

wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material,

wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and

wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin and metalized ceramic.

REMARKS

Claims 1-19, 22, 24, 26 and 27 are pending in this application. Claims 1, 3, 22, 24, 26 and 27 are independent. Claims 1-19, 22 and 24 were pending prior to the Office Action. In this Reply, claims 1, 3, 22 and 24 have been amended. New claims 26 and 27 have been added.

The Examiner is respectfully requested to reconsider the rejections in view of the amendments and remarks set forth herein. Applicants respectfully request favorable consideration thereof in light of the amendments and comments contained herein, and earnestly seek timely allowance of the pending claims.

Current Office Action is Non-Final

It is noted that the present Office Action dated March 12, 2013 is Non-Final, as indicated in Examiner's Interview Summary of April 12, 2013, in which the Examiner withdrew the premature finality of the present Office Action.

Claim Rejections – 35 USC § 103

The Examiner rejected claims 1-3, 7, 9, 10, 12-14, 22 and 24 under 35 U.S.C. § 103(a) as being unpatentable over US Patent 4,992,704 ("Stinson") in view of US Patent 6,600,175 ("Baretz et al.") and US 5,221,984 ("Furuyama"). The Examiner rejected claims 4-6 and 8 under 35 U.S.C. § 103(a) as being unpatentable over Stinson in view of Baretz, Furuyama and US Patent 3,699,478 ("Pinnow"). The Examiner rejected claim 11 under 35 U.S.C. § 103(a) as being unpatentable over Stinson in view of Baretz, Furuyama and US Patent 5,594,751 ("Scott"). The Examiner rejected claims 15-17 under 35 U.S.C. § 103(a) as being unpatentable over Stinson in view of Baretz, Furuyama and US Patent 6,015,200 ("Ogura"). The Examiner rejected claims 18 and 19 under 35 U.S.C. § 103(a) as being unpatentable over Stinson, Baretz, Furuyama further in view of US 5,801,435 ("Otsuki").

Applicants respectfully traverse these rejections.

Without conceding the propriety of the Examiner's rejections, but merely to timely advance prosecution of the present application, Applicants have amended independent claims 1, 3, 22 and 24.

Specifically, claim 1 was amended to recite:

> A light emitting device comprising:
> a mount,
> a plurality of light emitting chips mounted on said mount in a recess formed in said mount,
> a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein
> said first region is in the vicinity of at least one of said light emitting chips, and
> said second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and
> a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light,
> wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero,
> wherein the main emission peak of said light emitting chips is within the range from 400 nm to 530 nm, and
> wherein said mount comprises a material which is one of iron, copper, copper-clad iron, copper-clad tin and metalized ceramic.

The claim amendments are supported by the description of phosphor concentration in the specification as filed (e.g., paragraphs [0105], [0140], [0169], [0199] therein). Also, the amendments to claim 22 that recite that the plurality of inner leads are electrically separated from the mount, each inner lead being connected to one of said light emitting chips, are supported by Figs. 1 and 2 and the specification description of the mount and leads. As an example, in Fig. 2, although the inner leads are attached to a mount, the inner leads are still electrically separated from the mount, because the mount includes an insulating material. In another embodiment, e.g., in Fig. 1, inner leads are electrically separated from a mount because, otherwise, an electric short circuit would occur between the mount and the inner lead.

To establish a *prima facie* case of obviousness, the Examiner has the burden of meeting the basic criterion that the prior art must teach or suggest all of the claim limitations. Regarding this basic criterion, the Applicants submit that Stinson, Baretz, Furuyama, Pinnow, Scott, Ogura and Otsuki and any combination thereof (assuming the references can be combined, which

Applicants do not admit) do not disclose or suggest, at least:

- a transparent material directly covering the light emitting chips, the transparent material including a first region and a second region, wherein the first region is in the vicinity of at least one of the light emitting chips, and the second region is in the vicinity of the surface of the transparent material and closer to the surface of the transparent material than the first region, and

- a phosphor is contained in the transparent material and absorbs a part of light emitted by the light emitting chips and emits light of wavelength different from that of the absorbed light, and a concentration of the phosphor in the first region in the transparent material is larger than a concentration of the phosphor in the second region in the transparent material, wherein the concentration of the phosphor in the second region in the transparent material is larger than zero.

In the Office Action, the Examiner asserted that Stinson discloses a mount which holds LED dies 7, 8 and 9 and that the molded solid epoxy 11 is a transparent material covering the light emitting chips.

The Examiner used Baretz in connection with the previously-recited phosphor concentration features. Specifically, with respect to Baretz, the Examiner alleged that the collection of the down-converting material region 20 and the light-transmissive housing 11 of Baretz in Fig. 1 form a transparent material as in claim 1, in which portion 20 is a "first region" in the vicinity of the LED 13, and portion 11 is a "second region" in the vicinity of the surface of the alleged transparent material, because a phosphor is in portion 20, while the housing 11 contains no phosphor.

Applicants submit that Baretz does not disclose the features the Examiner asserted, because housing 11 of Baretz is not part of a transparent material that contains a phosphor. Housing 11 does not belong to a transparent material which contains luminophoric medium 20, and therefore, the zero phosphor concentration in housing 11 is immaterial to the concentration variation features recited in claim 1. Examiner's interpretation of the housing 11 of Baretz being a transparent material as in claim 1 is unreasonable.

However, Applicants have herein amended claim 1 (and the other independent claims), without conceding the propriety of the Examiner's rejections, but merely to timely advance prosecution of the present application.

Baretz does not disclose the features of amended claim 1. In Baretz, the only transparent material that directly covers an LED is material 20. Housing 11 does not directly cover the LED. In fact, housing 11 covers an LED only indirectly. Thus, Baretz does not disclose a transparent material directly covering the light emitting chips, the transparent material including a first region and a second region between which the phosphor concentration varies.

Baretz has phosphor in the material 20, but has no phosphor in housing 11. Thus, Baretz does not disclose first and second regions of a transparent material as in claim 1, in which a concentration of the phosphor in the first region is larger than a concentration of the phosphor in the second region, the concentration of the phosphor in the second region in the transparent material still being larger than zero. Baretz does not describe a variation of phosphor concentration between regions inside material 20, as Baretz does not disclose that a concentration of a phosphor in a first region in the vicinity of LED die 13 is larger than a concentration of such phosphor in a second region in the vicinity of the surface of material 20 and inside the material 20.

Baretz does not disclose a transparent material and phosphor concentration as in claims 3, 22 and 24, either. Stinson, Furuyama, Pinnow, Scott, Ogura and Otsuki do not disclose a transparent material and phosphor concentration as in claims 1, 3, 22 and 24, either.

For all of the above reasons, taken alone or in combination, Applicants respectfully request reconsideration and withdrawal of the 35 U.S.C. § 103 rejections of claims 1, 3, 22 and 24. Claims 2 and 4-18 depend from claim 1 and are allowable at least by virtue of their dependency. Claim 19 depends from claim 3 and is allowable at least by virtue of its dependency.

New Claims

New claims 26 and 27 have been added through this Reply. From a review of the specification and claims, it is apparent that no new matter has been entered. The new claims are supported by the device figures in the disclosure.

Baretz, Stinson, Furuyama, Pinnow, Scott, Ogura and Otsuki do not disclose a transparent material directly covering said light emitting chips, said transparent material including a first region in the vicinity of at least one of said light emitting chips, and a second region in the vicinity of the surface of said transparent material, and a phosphor contained in said transparent material, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material.

In Baretz, the only transparent material that directly covers an LED chip is material 20. Housing 11 does not directly cover the LED. In fact, housing 11 covers an LED only indirectly. Thus, housing 11 is not a transparent material as recited in claims 26 and 27. Furthermore, material 20 does not have a variation of phosphor concentration therein.

In conclusion, Baretz does not disclose:

- a transparent material directly covering the light emitting chips,

- which transparent material includes a first region and a second region between which the phosphor concentration varies.

Applicants respectfully request that the new claims 26 and 27 be allowed.

CONCLUSION

In view of the above amendments and remarks, this application appears to be in condition for allowance and the Examiner is, therefore, requested to reexamine the application and pass the claims to issue.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Corina E. Tanasa, Registration No. 64,042, at telephone number (703) 208-4003, located in the Washington, DC area, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Dated: July 12, 2013

Respectfully submitted,

By ____________

D. Richard Anderson
Registration No.: 40,439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
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Suite 100 East
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Falls Church, Virginia 22040-0747
(703) 205-8000
Attorney for Applicant

Electronic Patent Application Fee Transmittal

Application Number:	12559042
Filing Date:	14-Sep-2009
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Filer:	David Richard Anderson/Patti Young
Attorney Docket Number:	0020-5147PUS7

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Independent claims in excess of 3	1201	2	420	840
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 1 month with $0 paid	1251	1	200	200
Miscellaneous:				
		Total in USD ($)		**1040**

Electronic Acknowledgement Receipt

EFS ID:	16305047
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	David Richard Anderson/Patti Young
Filer Authorized By:	David Richard Anderson
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	12-JUL-2013
Filing Date:	14-SEP-2009
Time Stamp:	16:32:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1040
RAM confirmation Number	3574
Deposit Account	022448
Authorized User	ANDERSON, RICHARD D.

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		20130713Amendment.pdf	735204 8bdd7ca449a79c6b994aa19a6fc3e79f840ce7d5	yes	16

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Extension of Time	2	2
Amendment/Req. Reconsideration-After Non-Final Reject	3	3
Claims	4	10
Applicant Arguments/Remarks Made in an Amendment	11	16

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Fee Worksheet (SB06)	fee-info.pdf	32167 b9e047b4756b359a9cf9d04b431a4790a918f067	no	2

Warnings:

Information:

Total Files Size (in bytes):	767371

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

FEE TRANSMITTAL

Complete if known	
Application Number	12/559,042 Conf. No.: 7704
Filing Date	September 14, 2009
First Named Inventor	Yoshinori SHIMIZU
Examiner Name	Raj R. Gupta
Art Unit	2829
Practitioner Docket No.	0020-5147PUS7

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) 1,040.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**Fees Paid ($)**
Utility	280	140*	70	600	300	150	720	360	180	0.00
Design	180	90	45	120	60	30	460	230	115	0.00
Plant	180	90	45	380	190	95	580	290	145	0.00
Reissue	280	140	70	600	300	150	2,160	1,080	540	0.00
Provisional	260	130	65	0	0	0	0	0	0	0.00

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	**Undiscounted Fee ($)**	**Small Entity Fee ($)**	**Micro Entity Fee ($)**
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims 23 -20 or HP = **Extra Claims** 0 x **Fee ($)** 80.00 = **Fee Paid ($)** 0.00

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims 6 -3 or HP = **Extra Claims** 2 x **Fee ($)** 420.00 = **Fee Paid ($)** 840.00

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims
Fee ($) 0.00 **Fee Paid ($)** 0.00

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets ____ - 100 = **Extra Sheets** ____ / 50 = **Number of each additional 50 or fraction thereof** ____ (round **up** to a whole number) x **Fee ($)** ____ = **Fee Paid ($)** 0.00

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $130 fee (no small or micro entity discount) 0.00

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity) ____

Other (e.g., late filing surcharge): 1251 - 1 mo. EOT 200.00

SUBMITTED BY			
Signature	[signature]	Registration No. (Attorney/Agent) 40,439	Telephone 703-205-8000
Name (Print/Type)	D. Richard Anderson		Date July 12, 2013

ldf

PTO/AIA/22 (03-13)
Approved for use through 3/31/2013. OMB 0651-0031
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): 0020-5147PUS7

Application Number: 12/559,042

Filed: September 14, 2009

For: LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT

Art Unit: 2829

Examiner: Raj R. Gupta

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☑ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 200.00
☐ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☑ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 02-2448.

☐ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 40,439.

☐ attorney or agent acting under 37 CFR 1.34. Registration number ______.

Signature: [signature] Date: July 12, 2013

Typed or printed name: D. Richard Anderson Telephone Number: 703-205-8000

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

ut

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/559,042	Filing Date 09/14/2009	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	07/12/2013	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 23	Minus	** 25	= 0	x $80 =	0
	Independent (37 CFR 1.16(h))	* 6	Minus	***4	= 2	x $420 =	840
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	**840**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/Tina J. Barden/

UNITED STATES DEPARTMENT OF COMMERCE
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Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

2292 7590 08/05/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	
ART UNIT	PAPER NUMBER
2829	

DATE MAILED: 08/05/2013

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

TITLE OF INVENTION: LIGHT EMITTING DEVICE AND DISPLAY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	11/05/2013

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

2292 7590 08/05/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

TITLE OF INVENTION: LIGHT EMITTING DEVICE AND DISPLAY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	11/05/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
GUPTA, RAJ R	2829	257-098000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________________
2 ____________________
3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:

❑ Issue Fee
❑ Publication Fee (No small entity discount permitted)
❑ Advance Order - # of Copies ____________________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

❑ A check is enclosed.
❑ Payment by credit card. Form PTO-2038 is attached.
❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________________ Date ______________________________

Typed or printed name ______________________________ Registration No. ______________________________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 08/05/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	
ART UNIT	PAPER NUMBER
2829	

DATE MAILED: 08/05/2013

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 12/559,042	Applicant(s) SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	Art Unit 2829	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment filed on 7/12/2013*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on______.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-19,22 and 24*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☒ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☒ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date 20130723.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date See Continuation Sheet
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date *20130723* .
5. ☒ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/RAJ R GUPTA/
Examiner, Art Unit 2829

Continuation of Attachment(s) 2. Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date: 3/18/2013 and 6/7/2013.

Examiner-Initiated Interview Summary	Application No. 12/559,042	Applicant(s) SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	Art Unit 2829	

All participants (applicant, applicant's representative, PTO personnel):

(1) RAJ R. GUPTA. (3)_____.

(2) Corinna Tanasa 64042. (4)_____.

Date of Interview: 22 July 2013.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☒102 ☒103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 26 and 27.

Identification of prior art discussed: all of record.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

The Examiner initiated the interview to indicate that all claims are in condition for allowance except for claims 26 and 27. Potential rejections for claims 26 and 27 were discussed in general terms. Agreement was reached to cancel claims 26 and 27 by Examiners Amendment.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/RAJ R GUPTA/
Examiner, Art Unit 2829

Attorney's Docket Number: 0020-5147PUS7

Filing Date: 9/14/2009

Claimed Domestic Priority:	7/29/1997 (08/902725 DIV)
	4/28/1999 (09/300315 DIV)
	12/10/1999 (09/458024 DIV)
	7/1/2003 (10/609402 DIV)
	2/8/2008 (12/028062 DIV)
Claimed Foreign Priority:	7/29/1996 (JP 08-198585)
	9/17/1996 (JP 08-244339)
	9/18/1996 (JP 08-245381)
	12/27/1996 (JP 08-359004)
	3/31/1997 (JP09-081010)

Applicant: Shimizu et al.

Examiner: Raj R. Gupta

DETAILED ACTION

This Office Action responds to the amendment filed on 7/12/2013.

Acknowledgment

1. The amendment filed on 7/12/2013, responding to the Office Action mailed on 3/12/2013, has been entered. The present Office Action is made with all the amendments being fully considered. Accordingly, pending in this Office Action are **claims 1-19, 22, 24, 26, and 27**.

Drawings

2. The drawings filed on 9/14/2009 are acceptable subject to correction of the informalities indicated below. In order to avoid abandonment of this application, correction is required in reply to the Office action. The correction will not be held in abeyance.

3. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the first and second regions of the claimed a transparent material, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

4. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as "amended." If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will

be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

EXAMINER'S AMENDMENT

5. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

6. Authorization for this examiner's amendment was given in a telephone interview with Corina Tanasa (Reg. No. 64042) on 7/22/2013.

7. The application has been amended as follows:

a. In the claims:

i. Cancel **claims 26 and 27**.

Allowable Subject Matter

8. **Claims 1-19, 22, and 24** are allowed.

9. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

10. The following is an examiner's statement of reasons for allowance: the prior art of record does not anticipate nor render obvious the claimed a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein said first region is in the vicinity of at least one of said light emitting chips, and said second region is in the vicinity of the surface of said transparent material, closer to the surface of

said transparent material than said first region, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of wavelength different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero, when taken in concert with all the other limitations of claims, or equivalents as set forth in each independent claim.

11. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

12. Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAJ R. GUPTA whose telephone number is (571)270-5707. The examiner can normally be reached on Monday-Thursday 9am-6pm.

13. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ha T. Nguyen can be reached on (571)272-1678. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

14. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR

system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/RAJ R GUPTA/
Examiner, Art Unit 2829
July 23, 2013

/HA TRAN T NGUYEN/
Supervisory Patent Examiner, Art Unit 2829

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number: Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	1	JP 59-067673 - A	04-17-1984	TOYO COMMUN EQUIP CO LT		☑
						☐
						☐
						☐
						☐
						☐

Examiner Signature	/Raj R Gupta/	Date Considered	07/23/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 2 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	2	Office Action dated April 11, 2013 for U.S. Application No. 12/575,155.	✓

Examiner Signature	/Raj R Gupta/	Date Considered	07/23/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1	"12559042"	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 17:55
S70	17460	(transparent near3 cover$4).clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:44
S71	1244918	((first or second or other or another) near4 (region or area or portion)).clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:45
S72	337	(phosphor near5 concentration).clm.	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:46
S73	461	S70 near4 S71	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:46
S74	0	S72 with S73	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:46
S75	0	S72 and S73	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:47
S76	2	S70 and S71 and S72	US-PGPUB; USPAT; UPAD	ADJ	ON	2013/07/23 16:47

7/23/2013 6:36:03 PM
C:\Users\rgupta1\Documents\EAST\Workspaces\12559042.wsp

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BIB DATA SHEET

CONFIRMATION NO. 7704

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/559,042	09/14/2009 **RULE**	257	2829	0020-5147PUS7

APPLICANTS

Yoshinori Shimizu, Naka-gun, JAPAN;
Kensho Sakano, Anan-shi, JAPAN;
Yasunobu Noguchi, Naka-gun, JAPAN;
Toshio Moriguchi, Anan-shi, JAPAN;

** **CONTINUING DATA** *************************

This application is a DIV of 12/028,062 02/08/2008 PAT 7682848
which is a DIV of 10/609,402 07/01/2003 PAT 7362048
which is a DIV of 09/458,024 12/10/1999 PAT 6614179
which is a DIV of 09/300,315 04/28/1999 PAT 6069440
which is a DIV of 08/902,725 07/29/1997 PAT 5998925

** **FOREIGN APPLICATIONS** *************************

JAPAN P 08-198585 07/29/1996
JAPAN P 08-244339 09/17/1996
JAPAN P 08-245381 09/18/1996
JAPAN P 08-359004 12/27/1996
JAPAN P 09-081010 03/31/1997

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** **

09/24/2009

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /RAJ R GUPTA/ Examiner's Signature	☐ Met after Allowance Initials	JAPAN	19	17	2

ADDRESS

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747
UNITED STATES

TITLE

LIGHT EMITTING DEVICE AND DISPLAY

FILING FEE RECEIVED	FEES	
2410	FEES: Authority has been given in Paper No.___________ to charge/credit DEPOSIT ACCOUNT No.___________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ____________ ☐ Credit

Index of Claims	Application/Control No. 12559042	Applicant(s)/Patent Under Reexamination SHIMIZU ET AL.
	Examiner RAJ R GUPTA	Art Unit 2829

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/27/2010	03/10/2011	02/28/2013	07/23/2013					
1	1	✓	✓	✓	=					
2	2	✓	✓	✓	=					
18	3	✓	✓	✓	=					
15	4	✓	✓	✓	=					
16	5	✓	✓	✓	=					
17	6	✓	✓	✓	=					
3	7	✓	✓	✓	=					
4	8	✓	✓	✓	=					
5	9	✓	✓	✓	=					
6	10	✓	✓	✓	=					
7	11	✓	✓	✓	=					
8	12	✓	✓	✓	=					
9	13	✓	✓	✓	=					
10	14	✓	✓	✓	=					
13	15	✓	✓	✓	=					
14	16	✓	✓	✓	=					
11	17	✓	✓	✓	=					
12	18	✓	✓	✓	=					
19	19	✓	✓	✓	=					
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	21		✓	-						
20	22		✓	✓	=					
	23		✓	-						
21	24		✓	✓	=					
	25		✓	-						
	26				-					
	27				-					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	**Art Unit**
	RAJ GUPTA	2814

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
257	88, 89, 99	7/26/2010	RG
	updated search	3/10/2011	RG
	updated search	2/28/2013	RG
	updated search	7/21/2013	RG

SEARCH NOTES

Search Notes	Date	Examiner
Inventor, Class, and Text Search in EAST	7/26/2010	RG
updated search	3/10/2011	RG
updated search	2/28/2013	RG
updated search	7/21/2013	RG

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	See EAST printout	7/23/2013	RG

/RAJ R GUPTA/
Examiner.Art Unit 2829

Issue Classification	Application/Control No. 12559042	Applicant(s)/Patent Under Reexamination SHIMIZU ET AL.
	Examiner RAJ R GUPTA	**Art Unit** 2829

CPC					
Symbol				**Type**	**Version**
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CPC Combination Sets							
Symbol				**Type**	**Set**	**Ranking**	**Version**
		/					
		/					

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	07/28/2013 (Date)	O.G. Print Claim(s): 1 / O.G. Print Figure: 2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	**Art Unit**
	RAJ R GUPTA	2829

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**
257	98

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
257	99				

INTERNATIONAL CLASSIFICATION

CLAIMED					NON-CLAIMED				
H	0	1	L	33 / 50 (2010.0)					
H	0	1	L	33 / 52 (2010.0)					

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	07/28/2013 (Date)	O.G. Print Claim(s): 1 / O.G. Print Figure: 2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	**Art Unit**
	RAJ R GUPTA	2829

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	11	17												
2	2	12	18												
18	3	19	19												
15	4		20												
16	5		21												
17	6	20	22												
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6	10		26												
7	11		27												
8	12														
9	13														
10	14														
13	15														
14	16														

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21	
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	07/28/2013 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 2

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number Number - Kind Code [2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2006/0197098 - A1	09-07-2006	Aihara	
	2	US-3,875,473 - A	04-01-1975	Lebailly	
	3	US-4,849,630 - A	07-18-1989	Fukai et al.	
	4	US-5,334,855	08-02-1994	Moyer et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country [3] Code	Number [4] Kind Code (if known) [5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	5	EP	1681728 - A1	07-19-2006			☐
	6	WO	2005/109532 - A1	11-17-2005			☐
	7	WO	2010/023840 - A1	03-04-2010			☐
	8	GB	2098002 - A	11-10-1982			☐
	9	JP	7-183581 - A	07-21-1995			☑
							☐

Examiner Signature	/Raj R Gupta/	Date Considered	07/23/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

Sheet 2 of 2

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.1	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 2
	10	European Search Report for European Application No. 10158422.5 dated December 19, 2012.	
	11	European Search Report for European Application No. 10158429.0 dated December 19, 2012.	
	12	European Search Report for European Application No. 10158437.3 dated January 3, 2013.	
	13	European Search Report for European Application No. 10158449.8 dated January 3, 2013.	
	14	European Search Report for European Application No. 10158455.5 dated January 3, 2013.	
	15	US Office Action for US Application No. 12/689,681, dated February 5, 2013.	
	16	US Office Action for US Application No. 12/947,470, dated January 14, 2013.	

Examiner Signature	/Raj R Gupta/	Date Considered	07/23/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	12/559,042
Filing Date	09-14-09
First Named Inventor	Yoshinori Shimizu
Art Unit	2829
Examiner Name	Raj R. Gupta
Attorney Docket Number	0020-5147PUS7

Sheet 1 of 1

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	S-S. Sun, et al., "Electroluminescence and Photoluminescence of Cerium-Activated Alkaline Earth Thiogallate Thin Films and Devices", Pages 2877-2883, J. Electrochem. Soc. 141, No. 10, October 1994, The Electrochemical Society, Inc.	☑
	2	U.S. Office Action, mailed on August 27, 2013 for co-pending U.S. Application No. 12/575,155.	☐
	3	U.S. Office Action, mailed on June 11, 2013 for co-pending U.S. Application No. 12/947,470.	☐
	4	U.S. Office Action, mailed on June 14, 2013 for co-pending U.S. Application No. 12/689,681.	☐
	5	U.S. Office Action, mailed on June 17, 2013, for co-pending U.S. Application No.13/210,027.	☐
			☐
			☐
			☐
			☐
			☐

Examiner Signature		Date Considered	

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

of

Electronic Patent Application Fee Transmittal

Application Number:	12559042
Filing Date:	14-Sep-2009
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Filer:	Esther Hyeri Chong
Attorney Docket Number:	0020-5147PUS7

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt

EFS ID:	16816538
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Esther Hyeri Chong
Filer Authorized By:	
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	10-SEP-2013
Filing Date:	14-SEP-2009
Time Stamp:	18:05:04
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$180
RAM confirmation Number	5880
Deposit Account	022448
Authorized User	ANDERSON, RICHARD D.

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		0020-5147PUS7IDS.pdf	292580 f369112b81cca8b08f87638ad0b3ba7ab2c a8aa5	yes	8

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Transmittal Letter	2	7
Information Disclosure Statement (IDS) Form (SB08)	8	8

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Non Patent Literature	IDSNPLSun.pdf	726199 4135d3c4ec0035d3b1042bf949ce7c7ad64 3d96f	no	7

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Non Patent Literature	IDSUSOA13210027.pdf	650284 6f5110c9e80a1e1c86eb737d0f0e39dcdc6b 970b	no	15

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Non Patent Literature	IDSUSOA12689681.pdf	1588987 fab4c59aaecff2b7374a78863fc98383d0f47 896	no	22

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
5	Non Patent Literature	IDSUSOA12575155.pdf	362947 33a6165b436c1a3ee44f5103cbc88952f603 3fef	no	12

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
6	Non Patent Literature	IDSUSOA12947470.pdf	734454 766658844e5d59e87e6f8e1cbc37136beca eb80c	no	18

Warnings:

Information:

7	Fee Worksheet (SB06)	fee-info.pdf	30192 a592a3227f8e0e834628d03639e5450a46435248	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	4385643		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

FEE TRANSMITTAL

Complete if known	
Application Number	12/559,042 Conf. No.: 7704
Filing Date	September 14, 2009
First Named Inventor	Yoshinori SHIMIZU
Examiner Name	Raj R. Gupta
Art Unit	2829
Practitioner Docket No.	0020-5147PUS7

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) 180.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____________

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**Fees Paid ($)**
Utility	280	140*	70	600	300	150	720	360	180	
Design	180	90	45	120	60	30	460	230	115	
Plant	180	90	45	380	190	95	580	290	145	
Reissue	280	140	70	600	300	150	2,160	1,080	540	
Provisional	260	130	65	0	0	0	0	0	0	

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	**Undiscounted Fee ($)**	**Small Entity Fee ($)**	**Micro Entity Fee ($)**
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims ______ -20 or HP = **Extra Claims** ______ x **Fee ($)** ______ = **Fee Paid ($)** ______

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims ______ -3 or HP = **Extra Claims** ______ x **Fee ($)** ______ = **Fee Paid ($)** ______

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims **Fee ($)** ______ **Fee Paid ($)** ______

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets ______ - 100 = **Extra Sheets** ______ / 50 = **Number of each additional 50 or fraction thereof** ______ (round **up** to a whole number) x **Fee ($)** ______ = **Fee Paid ($)** ______

4. OTHER FEE(S) **Fees Paid ($)**

Non-English specification, $130 fee (no small or micro entity discount) ______

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity) ______

Other (e.g., late filing surcharge): Information Disclosure Statement (IDS) Fee ($180) 180.00

SUBMITTED BY				
Signature	Corina Tanasa Reg. NO. 64042	Registration No. (Attorney/Agent)	40439	Telephone 703-205-8000
Name (Print/Type) for	D. Richard Anderson CORINA TANASA			Date SEP 10 2013

ct

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Yoshinori SHIMIZU et al.

Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicant(s) hereby submit(s) an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. **Copies of foreign patent documents, non-patent literature and other information are provided.**

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☐ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

A copy of a U.S. Office Action, mailed on June 14, 2013, for co-pending U.S. Application No. 12/689,681 is provided. WO 1998/005078 is listed in this Office Action, but corresponds to US 5,998,925 A, filed via IDS on December 4, 2009, and which is a parent of the present application. The following references are also listed in this Office Action but were previously cited via IDS accordingly:

Filed via IDS on September 14, 2009

- **US 3,691,482 A**
- **US 3,699,478 A**
- **US 6,004,001 A**

Filed via IDS on December 4, 2009

- **US 5,998,925 A**

Cited in the Office Action issued in this application mailed August 2, 2010

- **US 6,600,175 A**

A copy of a U.S. Office Action, mailed on August 27, 2013, for co-pending U.S. Application No. 12/575,155 is provided. Reference U.S. 5,966,393 A is listed in the U.S. Office Action 12/575,155 but was previously filed via IDS in this application on April 5, 2012.

A copy of a U.S. Office Action, mailed on June 11, 2013, for co-pending U.S. Application No. 12/947,470 is provided.

A copy of a U.S. Office Action, mailed on June 17, 2013, for co-pending U.S. Application No. 13/210,027 is provided.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ c. **No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than three months prior to the filing of the IDS**; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than **thirty days** prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☐ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☐ d. This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance or before an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(c)(1)).

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☐ See the above statement. No fee is required.

☑ e. **This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance or after an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.**

VII. PAYMENT OF FEES

☑ **The required fee is listed on the attached Fee Transmittal.**

☐ No fee is required.

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: SEP 10 2013

Respectfully submitted,

By Corina Tanasa Reg. No. 64042

for D. Richard Anderson CORINA TANASA

Registration No.: 40439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Attachment(s):

- ☑ **PTO/SB/08**
- ☑ **One (1) NPL Reference**
- ☐ Foreign Patent Office Communication(s)
- ☐ Foreign Search Report(s)
- ☑ **One (1) Fee Transmittal**
- ☑ Other: **One (1) U.S. Office Action, mailed on June 11, 2013**
  One (1) U.S. Office Action, mailed on June 14, 2013
  One (1) U.S. Office Action, mailed on June 17, 2013
  One (1) U.S. Office Action, mailed on August 27, 2013

Substitute for form 1449B/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	**Application Number**	12/559,042
	Filing Date	09-14-09
	First Named Inventor	Yoshinori Shimizu
(Use as many sheets as necessary)	Art Unit	2829
	Examiner Name	Raj R. Gupta
Sheet 1 of 1	Attorney Docket Number	0020-5147PUS7

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	1	S-S. Sun, et al., "Electroluminescence and Photoluminescence of Cerium-Activated Alkaline Earth Thiogallate Thin Films and Devices", Pages 2877-2883, J. Electrochem. Soc. 141, No. 10, October 1994, The Electrochemical Society, Inc.	☑
	2	U.S. Office Action, mailed on August 27, 2013 for co-pending U.S. Application No. 12/575,155.	☐
	3	U.S. Office Action, mailed on June 11, 2013 for co-pending U.S. Application No. 12/947,470.	☐
	4	U.S. Office Action, mailed on June 14, 2013 for co-pending U.S. Application No. 12/689,681.	☐
	5	U.S. Office Action, mailed on June 17, 2013, for co-pending U.S. Application No.13/210,027.	☐
			☐
			☐
			☐
			☐
			☐

Examiner Signature	/Raj R Gupta/	Date Considered	09/25/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 09/30/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	

ART UNIT	PAPER NUMBER
2829	

NOTIFICATION DATE	DELIVERY MODE
09/30/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

PTOL-90A (Rev. 04/07)

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Trademark Office
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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
12/559,042	14 September, 2009	SHIMIZU ET AL.	0020-5147PUS7

		EXAMINER	
BIRCH STEWART KOLASCH & BIRCH, LLP PO BOX 747 FALLS CHURCH, VA 22040-0747		RAJ R. GUPTA	
		ART UNIT	PAPER
		2829	20130925

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

The information disclosure statement (IDS) submitted on 9/10/2013 was filed after the mailing date of the Notice of Allowance on 8/5/2013. The submission is in compliance with the provisions of 37 CFR 1.97. Accordingly, the information disclosure statement is being considered by the examiner.

/HA TRAN T NGUYEN/ Supervisory Patent Examiner, Art Unit 2829	/RAJ R GUPTA/ Examiner, Art Unit 2829

PTO-90C (Rev.04-03)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
12/559,042	09/14/2009	2829	2410	0020-5147PUS7	17	2

CONFIRMATION NO. 7704

CORRECTED FILING RECEIPT

OC000000064209913

2292
BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

Date Mailed: 10/04/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Yoshinori Shimizu, Naka-gun, JAPAN;
Kensho Sakano, Anan-shi, JAPAN;
Yasunobu Noguchi, Naka-gun, JAPAN;
Toshio Moriguchi, Anan-shi, JAPAN;

Applicant(s)

Yoshinori Shimizu, Naka-gun, JAPAN;
Kensho Sakano, Anan-shi, JAPAN;
Yasunobu Noguchi, Naka-gun, JAPAN;
Toshio Moriguchi, Anan-shi, JAPAN;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a DIV of 12/028,062 02/08/2008 PAT 7682848
which is a DIV of 10/609,402 07/01/2003 PAT 7362048
which is a DIV of 09/458,024 12/10/1999 PAT 6614179
which is a DIV of 09/300,315 04/28/1999 PAT 6069440
which is a DIV of 08/902,725 07/29/1997 PAT 5998925

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
JAPAN P 08-198585 07/29/1996
JAPAN P 08-244339 09/17/1996
JAPAN P 08-245381 09/18/1996
JAPAN P 08-359004 12/27/1996
JAPAN P 09-081010 03/31/1997

Request to Retrieve - This application either claims priority to one or more applications filed in an intellectual property Office that participates in the Priority Document Exchange (PDX) program or contains a proper **Request to Retrieve Electronic Priority Application(s)** (PTO/SB/38 or its equivalent). Consequently, the USPTO will attempt to electronically retrieve these priority documents.

If Required, Foreign Filing License Granted: 09/24/2009

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 12/559,042**

Projected Publication Date: Not Applicable

Non-Publication Request: No

Early Publication Request: No
Title

LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT

Preliminary Class

257

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

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LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

2292 7590 08/05/2013
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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

TITLE OF INVENTION: ~~LIGHT EMITTING DEVICE AND DISPLAY~~
LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1780	$300	$0	$2080	11/05/2013

EXAMINER	ART UNIT	CLASS-SUBCLASS
GUPTA, RAJ R	2829	257-098000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Birch, Stewart,
2 Kolasch & Birch, LLP
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: NICHIA CORPORATION

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Anan-shi, JAPAN

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☒ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____

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- ☐ A check is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 02-2448 (enclose an extra copy of this form).

ct

PTOL-85 (Rev. 02/11)

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

NOTE: Absent a valid certification of Micro Entity Status (see form PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________________ Date November 5, 2013

Typed or printed name D. Richard Anderson Registration No. 40,439

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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Doc Code: TRAN.LET

Document Description: Transmittal Letter

PTO/SB/21 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	12/559,042	Conf. No.: 7704
Filing Date	September 14, 2009	
First Named Inventor	Yoshinori SHIMIZU	
Art Unit	2829	
Examiner Name	Raj R. Gupta	
Total Number of Pages in This Submission		
Attorney Docket Number	0020-5147PUS7	

ENCLOSURES *(Check all that apply)*

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [x] Amendment/Reply
  - [x] After Allowance
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [x] Drawings - New Sheet - Fig. 24
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	BIRCH, STEWART, KOLASCH & BIRCH, LLP		
Signature			
Printed name	D. Richard Anderson		
Date	November 5, 2013	Reg. No.	40439

CERTIFICATE OF TRANSMISSION/MAILING

I hereby certify that this correspondence is being facsimile transmitted to the USPTO or deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below:

Signature			
Typed or printed name		Date	

ut

Docket No.: 0020-5147PUS7
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Yoshinori SHIMIZU et al.

Application No.: 12/559,042	Confirmation No.: 7704
Filed: September 14, 2009	Art Unit: 2829
For: LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner: Raj R. GUPTA

AMENDMENT AFTER ALLOWANCE UNDER 37 C.F.R. § 1.312

MS Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

Prior to issuance of the patent, Applicants respectfully request entry on this amendment under 37 C.F.R. 1.312 for the above-captioned patent application.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Drawings begin on page 3 of this paper.

Remarks/Arguments begin on page 4 of this paper.

An Appendix including a drawing figure is attached following page 5 of this paper.

AMENDMENTS TO THE SPECIFICATION

Applicants have amended the specification.

Please replace paragraph [0083] on page 14 in the specification as filed, with the following rewritten paragraph:

[0083] Fig. 23 shows the emission spectrum of the light emitting diode of Example 11[[.]]<u>; and</u>

<u>Fig. 24 shows an exemplary embodiment of a light emitting device according to an embodiment of the present invention.</u>

AMENDMENTS TO THE DRAWINGS

The Examiner objected to the drawings on page 3 of the Notice of Allowance documents dated August 5, 2013.

Responsive to the Examiner's objection, Applicants are attaching hereto 1 sheet of a new drawing (Figure 24) that complies with the provisions of 37 C.F.R. § 1.121(d). The newly submitted drawing (Fig. 24) is labeled "New Sheet" in the page header, in compliance with 37 CFR § 1.84(c). No new matter is added.

Applicants respectfully request that the newly submitted drawing be accepted and that the objections to the drawings be reconsidered and withdrawn.

Attachment: New sheet

REMARKS

Claims 1-19, 22 and 24 are pending in the application.

Objection to the Drawings and Amendment to the Specification

The Examiner objected to the drawings on page 3 of the Notice of Allowance documents dated August 5, 2013.

Responsive to the Examiner's objection, Applicants are attaching hereto 1 sheet of a new drawing (Figure 24) that complies with the provisions of 37 C.F.R. § 1.121(d). The newly submitted drawing (Fig. 24) is labeled "New Sheet" in the page header, in compliance with 37 CFR § 1.84(c). No new matter is added, and the amendments made herein do not raise any new issues.

Applicants respectfully request that the newly submitted drawing be accepted and that the objections to the drawings be reconsidered and withdrawn.

In addition, the specification is herein amended to list the new drawing (Fig. 24) in the "Brief Description of the Drawings" section.

Entry of this Amendment under the provisions of 37 CFR 1.312 is in order and is earnestly solicited.

CONCLUSION

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Corina Tanasa, Registration Number 64,042, at telephone number (703) 208-4003, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.17; particularly, extension of time fees.

Dated: November 5, 2013

Respectfully submitted,

By ______________________

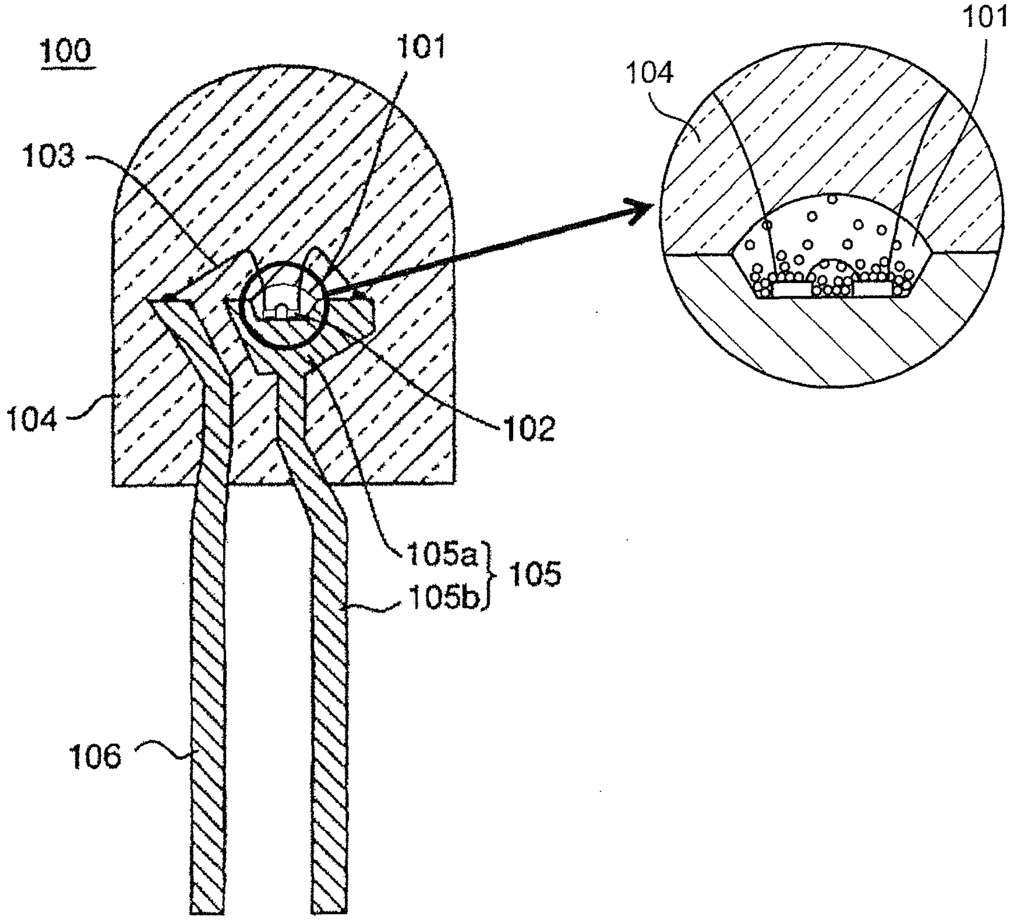
D. Richard Anderson
Registration No.: 40,439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road
Suite 100 East
P.O. Box 747
Falls Church, Virginia 22040-0747
(703) 205-8000
Attorney for Applicant

Attachments: Fig. 24 (New Sheet)

ct

NEW SHEET

FIG. 24



Electronic Patent Application Fee Transmittal

Application Number:	12559042
Filing Date:	14-Sep-2009
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Filer:	Esther Hyeri Chong
Attorney Docket Number:	0020-5147PUS7

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	1780	1780
Publ. Fee- Early, Voluntary, or Normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2080**

Electronic Acknowledgement Receipt

EFS ID:	17320795
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	Esther Hyeri Chong
Filer Authorized By:	
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	05-NOV-2013
Filing Date:	14-SEP-2009
Time Stamp:	16:28:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$2080
RAM confirmation Number	3621
Deposit Account	022448
Authorized User	ANDERSON, RICHARD D.

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		0020-5147PUS7ISSUEFEE.pdf	262681 8c287167aba63577428e67f403e5b5b6a431f3ba	yes	9

Multipart Description/PDF files in .zip description

Document Description	Start	End
Issue Fee Payment (PTO-85B)	1	2
Miscellaneous Incoming Letter	3	3
Amendment after Notice of Allowance (Rule 312)	4	4
Specification	5	5
Drawings-only black and white line drawings	6	6
Applicant Arguments/Remarks Made in an Amendment	7	8
Drawings-only black and white line drawings	9	9

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Fee Worksheet (SB06)	fee-info.pdf	31868 5b0f6cab5fa14cbf0082247128b51d4bd956b43a	no	2

Warnings:

Information:

Total Files Size (in bytes): 294549

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 11/08/2013
BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	
ART UNIT	PAPER NUMBER
2829	

NOTIFICATION DATE	DELIVERY MODE
11/08/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Applicant-Initiated Interview Summary	**Application No.** 12/559,042	**Applicant(s)** SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	**Art Unit** 2829	

All participants (applicant, applicant's representative, PTO personnel):

(1) RAJ R. GUPTA. (3)_____.

(2) Corina Tanasa 64042. (4)_____.

Date of Interview: 04 November 2013.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☐101 ☐112 ☐102 ☐103 ☒Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: none.

Identification of prior art discussed: none.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

The Applicant initiated the interview to request that the Objection to the Drawings made in the Office Action of 8/5/2013 be withdrawn. Ms Tanasa pointed out that while technically all claimed features must be shown in the drawings, this requirement is generally not rigidly enforced with regard to all the features of all the claims. The Examiner responded that in this case, the feature that is not shown in the drawings is the main point of novelty of the claims and the reason for allowance. The Objection was maintained. No agreements were reached.

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/RAJ R GUPTA/ Examiner, Art Unit 2829	/HA TRAN T NGUYEN/ Supervisory Patent Examiner, Art Unit 2829

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:
- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:
1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Docket No.: 0020-5147PUS7
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Yoshinori SHIMIZU et al.		
Application No.:	12/559,042	Confirmation No.:	7704
Filed:	September 14, 2009	Art Unit:	2829
For:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner:	Raj R. Gupta

STATEMENT OF THE SUBSTANCE OF THE INTERVIEW

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicants submit the following statement on the substance of the Interview held on November 4, 2013 with Examiner Raj Gupta.

On November 4 Applicants' representative called the Examiner regarding the drawing objection of August 5, 2013. Applicants' representative pointed out that a drawing is not necessary in this case for the concentration features which are recited in some of the claims, because the concentration features are fully understood from the specification disclosure.

An agreement with the Examiner was not reached.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: November 15, 2013

Respectfully submitted,

By ______________________

D. Richard Anderson
Registration No.: 40439
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

cet

Electronic Acknowledgement Receipt

EFS ID:	17421673
Application Number:	12559042
International Application Number:	
Confirmation Number:	7704
Title of Invention:	LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT
First Named Inventor/Applicant Name:	Yoshinori Shimizu
Customer Number:	2292
Filer:	David Richard Anderson/Ruth Calendine
Filer Authorized By:	David Richard Anderson
Attorney Docket Number:	0020-5147PUS7
Receipt Date:	15-NOV-2013
Filing Date:	14-SEP-2009
Time Stamp:	20:10:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant summary of interview with examiner	2013-11-15SubstanceofInterview.pdf	46249 c769fbc932560384b9393e36243dd5954b235fa1	no	2

Warnings:

Information:

Total Files Size (in bytes):	46249

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Index of Claims	Application/Control No. 12559042	Applicant(s)/Patent Under Reexamination SHIMIZU ET AL.
	Examiner RAJ R GUPTA	Art Unit 2829

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/27/2010	03/10/2011	02/28/2013	07/23/2013	11/12/2013				
1	1	✓	✓	✓	=	=				
2	2	✓	✓	✓	=	=				
18	3	✓	✓	✓	=	=				
15	4	✓	✓	✓	=	=				
16	5	✓	✓	✓	=	=				
17	6	✓	✓	✓	=	=				
3	7	✓	✓	✓	=	=				
4	8	✓	✓	✓	=	=				
5	9	✓	✓	✓	=	=				
6	10	✓	✓	✓	=	=				
7	11	✓	✓	✓	=	=				
8	12	✓	✓	✓	=	=				
9	13	✓	✓	✓	=	=				
10	14	✓	✓	✓	=	=				
13	15	✓	✓	✓	=	=				
14	16	✓	✓	✓	=	=				
11	17	✓	✓	✓	=	=				
12	18	✓	✓	✓	=	=				
19	19	✓	✓	✓	=	=				
	20		✓	-						
	21		✓	-						
20	22		✓	✓	=	=				
	23		✓	-						
21	24		✓	✓	=	=				
	25		✓	-						
	26				-					
	27				-					

Docket No.: 0020-5147PUS7
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Yoshinori SHIMIZU et al.

Application No.: 12/559,042	Confirmation No.: 7704
Filed: September 14, 2009	Art Unit: 2829
For: LIGHT EMITTING DEVICE AND DISPLAY COMPRISING A PLURALITY OF LIGHT EMITTING COMPONENTS ON MOUNT	Examiner: Raj R. GUPTA

AMENDMENT AFTER ALLOWANCE UNDER 37 C.F.R. § 1.312

MS Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

INTRODUCTORY COMMENTS

Prior to issuance of the patent, Applicants respectfully request entry on this amendment under 37 C.F.R. 1.312 for the above-captioned patent application.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Drawings begin on page 3 of this paper.

Remarks/Arguments begin on page 4 of this paper.

An Appendix including a drawing figure is attached following page 5 of this paper.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	Art Unit
	RAJ GUPTA	2814

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
257	88, 89, 99	7/26/2010	RG
	updated search	3/10/2011	RG
	updated search	2/28/2013	RG
	updated search	7/21/2013	RG

SEARCH NOTES

Search Notes	Date	Examiner
Inventor, Class, and Text Search in EAST	7/26/2010	RG
updated search	3/10/2011	RG
updated search	2/28/2013	RG
updated search	7/21/2013	RG

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	See EAST printout	7/23/2013	RG

/RAJ R GUPTA/ Examiner.Art Unit 2829	

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/559,042	09/14/2009	Yoshinori Shimizu	0020-5147PUS7	7704

2292 7590 11/20/2013
BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
GUPTA, RAJ R	
ART UNIT	**PAPER NUMBER**
2829	
NOTIFICATION DATE	**DELIVERY MODE**
11/20/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

PTOL-90A (Rev. 04/07)

Corrected *Notice of Allowability*	**Application No.** 12/559,042	**Applicant(s)** SHIMIZU ET AL.	
	Examiner RAJ R. GUPTA	**Art Unit** 2829	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment filed on 11/5/2013*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on______.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-19,22 and 24*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☒ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/RAJ R GUPTA/
Examiner, Art Unit 2829

Attorney's Docket Number: 0020-5147PUS7

Filing Date: 9/14/2009

Claimed Domestic Priority:	7/29/1997 (08/902725 DIV)
	4/28/1999 (09/300315 DIV)
	12/10/1999 (09/458024 DIV)
	7/1/2003 (10/609402 DIV)
	2/8/2008 (12/028062 DIV)
Claimed Foreign Priority:	7/29/1996 (JP 08-198585)
	9/17/1996 (JP 08-244339)
	9/18/1996 (JP 08-245381)
	12/27/1996 (JP 08-359004)
	3/31/1997 (JP09-081010)

Applicant: Shimizu et al.

Examiner: Raj R. Gupta

DETAILED ACTION

This Office Action responds to the amendment filed on 11/5/2013.

Acknowledgment

1. The amendment filed on 11/5/2013, responding to the Office Action mailed on 8/5/2013, has been entered. The present Office Action is made with all the amendments being fully considered.

Drawings

2. The drawings were received on 11/5/2013. These drawings are acceptable.

EXAMINER'S AMENDMENT

3. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

4. Authorization for this examiner's amendment was given in a telephone interview with Corina Tanasa (Reg. No. 64042) on 7/22/2013.

5. The application has been amended as follows:

a. In the claims:

i. Cancel **claims 26 and 27**.

Allowable Subject Matter

6. **Claims 1-19, 22, and 24** are allowed.

7. As allowable subject matter has been indicated, applicant's reply must either comply with all formal requirements or specifically traverse each requirement not complied with. See 37 CFR 1.111(b) and MPEP § 707.07(a).

8. The following is an examiner's statement of reasons for allowance: the prior art of record does not anticipate nor render obvious the claimed a transparent material directly covering said light emitting chips, said transparent material including a first region and a second region, wherein said first region is in the vicinity of at least one of said light emitting chips, and said second region is in the vicinity of the surface of said transparent material, closer to the surface of said transparent material than said first region, and a phosphor contained in said transparent material and absorbing a part of light emitted by said light emitting chips and emitting light of

wavelength different from that of the absorbed light, wherein a concentration of said phosphor in said first region in said transparent material is larger than a concentration of said phosphor in said second region in said transparent material, wherein the concentration of said phosphor in said second region in said transparent material is larger than zero, when taken in concert with all the other limitations of claims, or equivalents as set forth in each independent claim.

9. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

10. Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAJ R. GUPTA whose telephone number is (571)270-5707. The examiner can normally be reached on Monday-Thursday 9am-6pm.

11. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ha T. Nguyen can be reached on (571)272-1678. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

12. Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would

like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/RAJ R GUPTA/
Examiner, Art Unit 2829
November 12, 2013

/HA TRAN T NGUYEN/
Supervisory Patent Examiner, Art Unit 2829

Response to Rule 312 Communication	Application No. 12/559,042	Applicant(s) SHIMIZU ET AL.
	Examiner RAJ R. GUPTA	Art Unit 2829

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

1. ☒ The amendment filed on *05 November 2013* under 37 CFR 1.312 has been considered, and has been:

   a) ☒ entered.

   b) ☐ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

/HA TRAN T NGUYEN/ Supervisory Patent Examiner, Art Unit 2829	/RAJ R GUPTA/ Examiner, Art Unit 2829

Issue Classification	Application/Control No. 12559042	Applicant(s)/Patent Under Reexamination SHIMIZU ET AL.
	Examiner RAJ R GUPTA	Art Unit 2829

CPC		
Symbol	Type	Version
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CPC Combination Sets				
Symbol	Type	Set	Ranking	Version
/				
/				

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	11/13/2013 (Date)	O.G. Print Claim(s): 1 O.G. Print Figure: 24

Issue Classification	**Application/Control No.** 12559042	**Applicant(s)/Patent Under Reexamination** SHIMIZU ET AL.
	Examiner RAJ R GUPTA	**Art Unit** 2829

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
257	98

INTERNATIONAL CLASSIFICATION									
CLAIMED					NON-CLAIMED				
H	0	1	L	33 / 50 (2010.01.01)					
H	0	1	L	33 / 52 (2010.01.01)					

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
257	99				

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	11/13/2013 (Date)	O.G. Print Claim(s): 1 / O.G. Print Figure: 24

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12559042	SHIMIZU ET AL.
	Examiner	**Art Unit**
	RAJ R GUPTA	2829

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	11	17												
2	2	12	18												
18	3	19	19												
15	4		20												
16	5		21												
17	6	20	22												
3	7		23												
4	8	21	24												
5	9		25												
6	10		26												
7	11		27												
8	12														
9	13														
10	14														
13	15														
14	16														

/RAJ R GUPTA/ Examiner.Art Unit 2829 (Assistant Examiner)	07/23/2013 (Date)	**Total Claims Allowed:** 21	
/HA TRAN T NGUYEN/ Supervisory Patent Examiner.Art Unit 2829 (Primary Examiner)	11/13/2013 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 24

Receipt date: 09/14/2009 12559042 - GAU: 2814

SEP 14 2009

Used in Lieu of PTO/SB/08A/B
(Based on PTO 01-08 version)

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				**Application Number**	NEW
				Filing Date	SEP 14 2009
				First Named Inventor	Yoshinori SHIMIZU
				Art Unit	N/A
(Use as many sheets as necessary)				Examiner Name	Not Yet Assigned
Sheet	1	of	5	Attorney Docket Number	0020-5147PUS7

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Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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Change(s) applied to document, /D.S.D./ 10/11/2013

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /R.R.G

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Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	12/559,042, Conf. #7704
				Filing Date	September 14, 2009
				First Named Inventor	Yoshinori SHIMIZU
				Art Unit	2812
(Use as many sheets as necessary)				Examiner Name	Not Yet Assigned
Sheet	1	of	3	Attorney Docket Number	0020-5147PUS7

Change(s) applied to document, /D.S.D./ 10/11/2013

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Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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Examiner Signature	/Raj R Gupta/	Date Considered	07/27/2010

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. * CITE NO.: Those application(s) which are marked with an single asterisk (*) next to the Cite No. are not supplied (under 37 CFR 1.98(a)(2)(iii)) because that application was filed after June 30, 2003 or is available in the IFW. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

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