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**Reeh et al.**

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(54) **LIGHT-RADIATING SEMICONDUCTOR COMPONENT WITH A LUMINESCENCE CONVERSION ELEMENT**

2,192,869 A \* 3/1940 Pearce ..... 313/485  
3,312,851 A 4/1967 Flowers et al.  
3,316,109 A 4/1967 Rimbach  
3,440,471 A 4/1969 Baczewski et al.

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(Continued)

**FOREIGN PATENT DOCUMENTS**

BE 1 007 825 10/1995  
DE 1915290 10/1969  
DE 2018353 C 10/1970

(Continued)

(73) Assignee: **Osram GmbH** (DE)

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**OTHER PUBLICATIONS**

This patent is subject to a terminal disclaimer.

*Jour. Solid State Chemistry* "White Light Emitting Glasses" Chao et al pp 17-29 1991.\*

Sato et al "Full-Color Diode" *Jpn. J. Appl. Phys.* vol. 35 (1996) pp L838-L839, Jul. 1996.\*

Robbins et al., Single Crystal Y3A15O12: Tb Phosphor Produced by Ion Implantation., *Journal of the Electrochemical Society*, vol. 129, No. 4, pp. 816-820.

(Continued)

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(57) **ABSTRACT**

(51) **Int. Cl.**  
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The light-radiating semiconductor component has a radiation-emitting semiconductor body and a luminescence conversion element. The semiconductor body emits radiation in the ultraviolet, blue and/or green spectral region and the luminescence conversion element converts a portion of the radiation into radiation of a longer wavelength. This makes it possible to produce light-emitting diodes which radiate polychromatic light, in particular white light, with only a single light-emitting semiconductor body. A particularly preferred luminescence conversion dye is YAG:Ce.

(52) **U.S. Cl.** ..... **257/98**; 257/89

(58) **Field of Classification Search** ..... 257/89,  
257/98

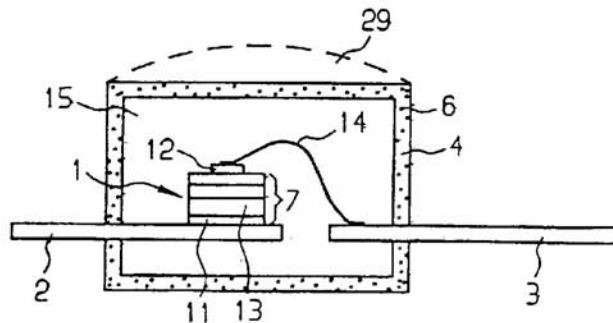
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

2,096,693 A \* 10/1937 Cox ..... 313/485

**33 Claims, 6 Drawing Sheets**



U.S. PATENT DOCUMENTS

3,453,604	A	7/1969	Geusic et al.	
3,483,416	A	12/1969	Vermeulen	
3,510,732	A	5/1970	Amans .....	257/77
3,529,200	A	9/1970	Potter et al.	
3,565,815	A	2/1971	Christy	
3,573,568	A	4/1971	Siegel	
3,593,055	A	* 7/1971	Geusic .....	257/98
3,602,758	A	* 8/1971	Thornton .....	313/485
3,621,340	A	11/1971	Singh	
3,654,463	A	4/1972	Geusic	
3,659,136	A	4/1972	Grodkiewicz	
3,691,482	A	* 9/1972	Pinnow .....	330/108
3,699,478	A	10/1972	Pinnow et al.	
3,700,479	A	10/1972	Arents	
3,715,611	A	2/1973	De Mesquita et al.	
3,740,616	A	6/1973	Suzuki et al.	
3,742,277	A	6/1973	Peters	
3,742,833	A	7/1973	Sewell et al.	
3,743,833	A	7/1973	Mantic et al.	
3,774,086	A	11/1973	Vincent, Jr.	
3,787,684	A	1/1974	Isenberg	
3,819,974	A	6/1974	Stevenson et al.	
3,822,215	A	7/1974	Grodkiewicz	
3,875,456	A	4/1975	Kano et al. ....	313/501
3,932,881	A	* 1/1976	Mita .....	257/98
3,976,877	A	8/1976	Thillays	
4,093,890	A	6/1978	Verriet et al.	
4,139,657	A	2/1979	Watanabe	
4,203,792	A	5/1980	Thompson	
4,262,206	A	4/1981	Viehmann	
4,298,820	A	11/1981	Bongers et al. ....	313/463
4,307,297	A	12/1981	Groff et al.	
4,479,886	A	10/1984	Kasenga .....	252/301.4
4,599,537	A	7/1986	Yamashita	
4,684,592	A	8/1987	Matsuda et al.	
4,707,635	A	11/1987	Tateyama et al.	
4,710,674	A	12/1987	Sigai	
4,716,337	A	12/1987	Huiskes et al.	
4,727,283	A	2/1988	van Kemenade et al. ...	313/487
4,780,752	A	10/1988	Angerstein et al. ....	357/72
4,816,369	A	3/1989	Matsuda et al.	
4,818,434	A	4/1989	Lindmayer	
4,825,124	A	4/1989	Sigai	
4,843,280	A	6/1989	Lumbard et al.	
4,851,695	A	7/1989	Stein	
4,875,750	A	10/1989	Spaeth et al.	
4,894,583	A	1/1990	Berkstresser et al.	
4,935,856	A	6/1990	Dragoon	
5,003,181	A	3/1991	Morlotti et al.	
5,019,746	A	5/1991	Merg	
5,035,483	A	7/1991	Waitl et al.	
5,107,317	A	4/1992	Takasaki .....	357/30
5,126,214	A	* 6/1992	Tokaillin .....	313/503
5,196,763	A	3/1993	Yang et al.	
5,202,777	A	4/1993	Sluzky et al. ....	357/50
RE34,254	E	5/1993	Dragoon	
5,208,462	A	5/1993	O'Conner et al.	
5,256,725	A	10/1993	Takada et al.	
5,294,897	A	3/1994	Notani et al.	
5,379,186	A	1/1995	Gold et al.	
5,417,886	A	5/1995	Tateiwa et al.	
5,424,573	A	6/1995	Kato et al.	
5,432,358	A	7/1995	Nelson et al.	
5,471,113	A	11/1995	De Backer et al.	
5,479,050	A	12/1995	Pritchard et al.	
5,535,230	A	* 7/1996	Abe .....	257/98
5,543,657	A	8/1996	Diffenderfer et al.	
5,578,839	A	11/1996	Nakamura et al.	

5,624,602	A	4/1997	Lenox et al.	
5,635,110	A	6/1997	Chandha et al.	
5,643,674	A	7/1997	Bruno et al.	
5,665,793	A	9/1997	Anders	
5,685,071	A	11/1997	Gates, Jr. et al.	
5,707,549	A	1/1998	Matsukiyo et al.	
5,747,832	A	5/1998	Nakamura et al.	
5,772,916	A	6/1998	Jamil et al.	
5,788,881	A	8/1998	Chadha et al.	
5,798,537	A	8/1998	Nitta .....	257/103
5,813,752	A	9/1998	Singer et al.	
5,813,753	A	9/1998	Vriens et al.	
5,847,507	A	12/1998	Butterworth et al. ....	313/512
5,863,810	A	1/1999	Kaldenberg	
5,906,771	A	5/1999	Watkins et al.	
5,952,036	A	9/1999	Tadaki et al.	
5,959,316	A	* 9/1999	Lowery .....	257/98
5,994,722	A	11/1999	Averback et al.	
5,998,925	A	12/1999	Shimizu et al.	
6,069,440	A	5/2000	Shimizu et al. ....	313/486
6,180,029	B1	1/2001	Hampden-Smith et al.	
6,245,259	B1	6/2001	Hohn et al. ....	252/301.36
6,576,930	B1	6/2003	Reeh et al.	
6,600,175	B1	7/2003	Baretz et al. ....	257/100
6,613,247	B1	9/2003	Hohn et al. ....	252/301.36
6,812,500	B1	11/2004	Reeh et al.	
2001/0030326	A1	10/2001	Reeh et al.	
2004/0016938	A1	1/2004	Baretz et al. ....	257/100
2005/0127385	A1	6/2005	Reeh et al.	
2005/0161694	A1	7/2005	Reeh et al.	

FOREIGN PATENT DOCUMENTS

DE	2018354	C	10/1970
DE	2059909		6/1971
DE	718442		12/1971
DE	2 347 289		4/1974
DE	33 15 675	A1	11/1983
DE	38 04 293	A1	8/1989
DE	90 13 615		1/1991
EP	0039017	B1	8/1985
EP	0333162		9/1989
EP	0 387 715		9/1990
EP	0 486 052	A1	5/1992
EP	97 933 047.9		1/1999
EP	0936682		8/1999
FR	2004989		12/1969
FR	2043403		2/1971
FR	2044727		2/1971
FR	2073134		9/1971
GB	1263185		2/1972
GB	1317731		5/1973
GB	1317732		5/1973
GB	1332462		10/1973
GB	2000173		1/1979
GB	2149416		6/1985
JP	46-7462		12/1971
JP	47-017684		9/1972
JP	49-6962		3/1973
JP	46-39866		6/1973
JP	49-1221		1/1974
JP	49-122292		11/1974
JP	50-43913		4/1975
JP	50-74875		6/1975
JP	51145288		12/1976
JP	52-009334		1/1977
JP	52-9334		2/1977
JP	52-40959		10/1977
JP	53001180		1/1978
JP	53-100787		9/1978



JP	56-005884	1/1981	English Translation of Proceedings of 264 <sup>th</sup> Institute of Phosphor Society, "Development and Application of high bright white LED Lamps", Nov. 29, 1996, pp. 5-14.
JP	58-043584	3/1983	Journal of the Electrochemical Society, Solid-State Science and Technology, "Preparation of Y <sub>3</sub> Al <sub>5</sub> O <sub>12</sub> Based Phosphor Powders", Feb. 1987, pp. 493-498.
JP	61-240680	10/1986	Chao et al., "White Light Emitting Glass", Jour. Solid State Chemistry, p. 17-29.
JP	60090680	11/1986	Nakamura, SPIE, "Present performance of InGaN based blue/green/yellow LEDS", vol. 3002, 1997, pp. 26-35.
JP	61-248839	11/1986	A Dictionary of Metallurgy, p. 9, 1958.
JP	62-20237	1/1987	Japanese Internet Literature, "Preparing Nearly-Spherical Aluminate Phosphors of Uniform Size".
JP	62201989	9/1987	Course of Lectures: Fundamental and Application of Color Image Engineering, No. 5, Television Gakkaishi (The Journal of the Institute of Television Engineers of Japan), vol. 47, 1993, p. 753-764.
JP	2-91980	9/1988	R.W.G. Hunt, "Revised Colour-Appearance Model for Related and Unrelated Colours", Color Research and Application, vol. 14, 1991 p. 146-165.
JP	01175103	7/1989	Yoshinobu Nayatani, "Revision of the Chroma and Hue Scaled of a Nonlinear Color-Appearance Model", Color Research and Application, vol. 20, 1995, p. 143-155.
JP	01-179471	7/1989	Mitsuo Ikeda et al. "Equivalent Lightness of Colored Objects at Illuminances from the Scotopic to the Photopic Level", Color Research and Application, vol. 14, 1989, p. 198-206.
JP	01260707	10/1989	Mitsuo Ikeda et al., "Equivalent Lightness of Colored Objects of Equal Munsell Chroma and of Equal Munsell Value at Various Illuminances", Color Research and Application, vol. 16, 1991, p. 72-80.
JP	02011694	1/1990	Hiroyuki Shinoda et al., "Categorized Color Space on CRT in the Aperture and the Surface Color Mode", Color Research and Application, vol. 18, 1993, p. 326-333.
JP	2080970	3/1990	Change of Color Conspicuity for Various Illuminance Levels Effects of the Purkinje shift, Shomei Gakkaishi (Journal of the Illuminating Engineering Institute of Japan, vol. 17, 1987, p. 612-617.
JP	03220286	9/1991	Japanese Journal of Applied Physics, Part 2, vol. 31, No. 10B, 1992, p. L1457-L1459.
JP	03287690	12/1991	Philips Journal of Research, vol. 36, No. 1, 1981, p. 15-30.
JP	4110236	4/1992	Translation of JP 48-39866, May 18, 1973, Japan.
JP	04 063 162	5/1992	Translation of JP 6-0009, Aug. 19, 1994, Japan.
JP	04137570	5/1992	Translation of JP 5-50611, Jul. 2, 1993, Japan.
JP	4-175265	6/1992	Translation of JP 5-72553, Oct. 5, 1993, Japan.
JP	5-38926	5/1993	Excerpt from Nikkei Sangyo Shimbun; Sep. 13, 1996.
JP	5-152609	* 6/1993	Translation of "AP".
JP	05315652	11/1993	English Translation of Japanese 01175103 A, Jul. 11, 1989.
JP	05315653	11/1993	English Translation of Japanese 01260707 A, Oct. 18, 1989.
JP	05315624	12/1993	Phosphor Handbook, English Translation of (BAT).
JP	5-335624	12/1993	"Phosphor Handbook", Ohm 1987, pp. 172-174, 188-189, 270, 275-276, 383-385.
JP	05347432	12/1993	Nakamura, Shuji et al., Candela-class high-brightness InGaN/AlGaIn double-heterostructure blue-light-emitting diodes, App. Phys. Lett 64 (13) Mar. 28, 1994, pp. 1687-1689.
JP	6013075	1/1994	Nakamura, T, "Nichia Chemical starts the sample shipment of white light Emitting Diode", Nikkei Electronics, Sep. 23, 1996 (No. 671), pp. 15-16.
JP	6017130	1/1994	English translation of (BAV).
JP	06053554	2/1994	Schlotter, P. et al., "Luminescence conversion of blue light
JP	6-69546	3/1994	
JP	06076754	3/1994	
JP	6085314	3/1994	
JP	06 104491	4/1994	
JP	06163988	6/1994	
JP	06204570	7/1994	
JP	6-208845	7/1994	
JP	06306356	11/1994	
JP	7-99345	4/1995	
JP	7-42152	7/1995	
JP	7-176794	7/1995	
JP	7-193281	7/1995	
JP	07-292354	7/1995	
JP	8-7614	1/1996	
JP	08-007614	1/1996	
JP	8007614	1/1996	
JP	08-032120	2/1996	
JP	00864860	3/1996	
JP	08-096958	4/1996	
JP	198585/1996	7/1996	
JP	244339/1996	9/1996	
JP	245381/1996	9/1996	
JP	359004/1996	12/1996	
JP	09 027642	1/1997	
JP	09-028642	2/1997	
JP	9-73807	3/1997	
JP	081010/1997	3/1997	
JP	10 012925	1/1998	
JP	10-242513	9/1998	
JP	02-927279	7/1999	
JP	11-220174	8/1999	
WO	96/23030	8/1996	
WO	97/48138	12/1997	
WO	98/05078	5/1998	

## OTHER PUBLICATIONS

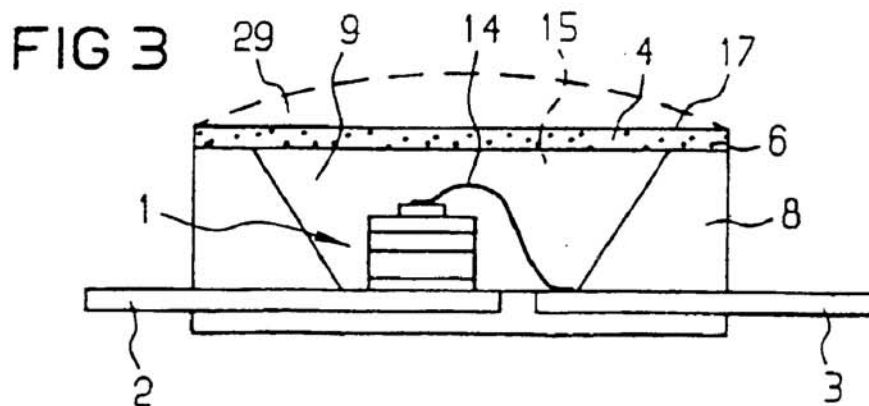
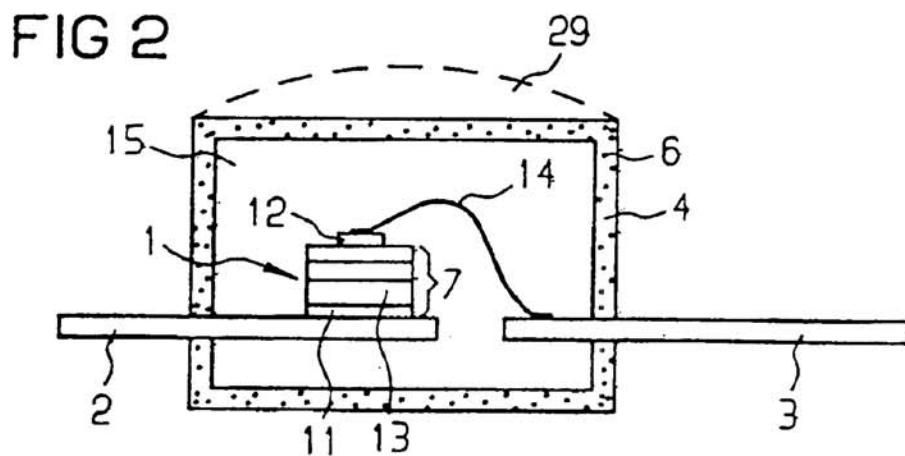
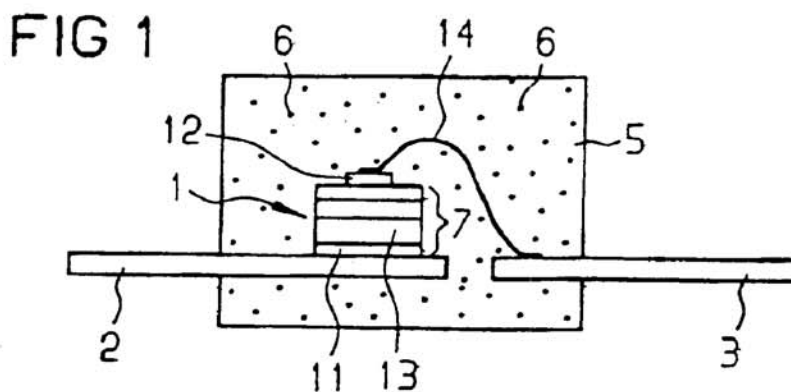
Poort et al., "Optical properties of Eu<sup>2+</sup>-activated orthosilicates and orthophosphates" *Journal of Alloys and Compounds*, vol. 260, No. 1-2, pp. 93-97 (Sep. 12, 1997).

Nakamura, T, "Nichia Chemical starts the sample shipment of white light Emitting Diode", Nikkei Electronics, Sep. 23, 1996 (No. 671), pp. 15-16.  
English translation of (BAV).  
Schlotter, P. et al., "Luminescence conversion of blue light

- Material Safety Data Sheet, pp. 1 and 2, and Lamp Phosphor Data Sheet of Phosphor NP-204 of Nichia Corporation. "Phosphor and Emitter", Osram GmbH, Jun. 1997.
- Proceedings of 264<sup>th</sup> Institute of Phosphor Society, "Development and Application of high bright white LED Lamps", Nov. 29, 1996, pp. 5-14.
- English Translation of (BAAA).
- English Translation of Japanese Patent Application No. 245381, Filed Sep. 18, 1996, Nichia Chemical Industries Ltd.
- English Translation of Japanese Patent Application No. 359004, Filed Dec. 27, 1996, Nichia Chemical Industries Ltd.
- English Translation of Japanese Patent Application No. 198585, Filed Jul. 29, 1996, Nichia Chemical Industries Ltd.
- English Translation of Japanese Patent Application No. 018010, Filed Mar. 31, 1997, Nichia Chemical Industries Ltd.
- Nikkei Sangyo Shimbum (Nikkei Industrial Newspaper), Sep. 13, 1996.
- English Abstract of Japanese 7-99345, Apr. 11, 1995.
- Siemens Forsch.-u. Entwickl.-Ber. Bd 6 (1977) No. 3, p. 162 [Siemens research and development reports, vol. 6].
- S. N. Mohammad et al.: "Emerging Gallium Nitride Based Devices", Proceedings of the IEEE, vol. 83, No. 10, Oct. 1995, pp. 1306-1355.
- German Utility Model G 90 13 615.2, dated Jan. 24, 1991, electroluminescent or laser diode.
- Japanese Patent Abstract No. 5-152609 (Tadatsu), dated Jun. 18, 1993.
- Japanese Patent Abstract 07176794 A (Yoshinori), dated Jul. 14, 1995.
- Japanese Patent Abstract 08007614 (Yoshinori), dated Jan. 12, 1996.
- Thomas Jüstel et al.: "Neue Entwicklungen auf dem Gebiet lumineszierender Materialien für Beleuchtungs- und Displayanwendungen" [new developments in the field of luminescent materials for lighting and display applications], Angew. Chem. 1998, 110 pp. 3250-3271.
- D.J. Robbins: "The Effects of Crystal Field and Temperature on the Photoluminescence Excitation of Ce<sup>3+</sup> in YAG", J. Electrochem. Soc.: Solid State Science and Technology, Sep. 1979, vol. 126, No. 9, pp. 1550-1555.
- Glen A. Slack et al.: "Optical Absorption of Y<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> from 10- to 55000-cm<sup>-1</sup> Wave Numbers", Physical review, vol. 177, No. 3, Jan. 15, 1969, pp. 1308-1314.
- Shuji Nakamura et al.: "The blue laser diode: GaN based light emitters and lasers", Springer Verlag, Berlin, 1997, pp. 216-219, 328.
- G. Blasse et al.: "A New Phosphor For Flying-Spot Cathode-Ray Tubes For Color Television: Yellow-Emitting Y<sub>3</sub>Al<sub>5</sub>O<sub>12</sub>-Ce<sup>3+</sup>", Applied Physics Letter, vol. 11, No. 2, Jul. 15, 1967, pp. 53,54.
- White LED Lamp by Nichia, copy of a Japanese Newspaper, dated Sep. 1996.
- Mary V. Hoffman: "Improved color rendition in high pressure mercury vapor lamps", Journal of IES, Jan. 1997, pp. 89-91.
- B. M. J. Smets: "Phosphors Based On Rare-Earths, A New Era in Fluorescent Lighting", Materials Chemistry and Physics, 16 (1987), pp. 283-299.
- Frank Möllmer et al.: "Siemens SMT-TOPLED für die Oberflächenmontage", [Siemens SMT-TOPLEDS for surface mounting], Siemens Components 29, 1991, No. 4, pp. 147-149.
- Summons and Complaint re: Citizen Electronics Company, Ltd. v. Osram GmbH and Osram Opto Semiconductors GmbH.
- Summons and Complaint re: Citizen Electronics Company, Ltd. v. Osram GmbH and Opto Semiconductors GmbH.
- Office Action from the Korean Patent Office dated Aug. 25, 2005.
- Möllmer et al., "Siemens SMT TOP-LED for Surface Mounting", *Siemens Components*, Bd. 26, No. 6, pp. 193-196 (1991).
- Translation of Japanese Office Action Dated Jun. 2, 2005.
- Notice of European Opposition Dated Feb. 28, 2005.
- Six European Search Reports dated May 25, 2005.
- In the Matter of Certain Light-Emitting Diodes and Products Containing Same*, Investigation No. 337-TA-512, "Notice of Commission Final Determination of No Violation of Section 337 as to One Patent and Determination to Remand the Investigation as Certain Other Patents," Dated Aug. 10, 2005.
- In the Matter of Certain Light-Emitting Diodes and Products Containing Same*, Investigation No. 337-TA-512, "Initial Determination on Violation of Section 337 and Recommended Determination on Remedy and Bond," (Public Version), Dated May 10, 2005.
- In the Matter of Certain Light-Emitting Diodes and Products Containing Same*, Investigation No. 337-TA-512, "Commission Opinion," (Public Version), Dated Aug. 29, 2005.

\* cited by examiner





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