



US006885035B2

(12) **United States Patent**
Bhat et al.

(10) **Patent No.:** **US 6,885,035 B2**
(45) **Date of Patent:** **Apr. 26, 2005**

(54) **MULTI-CHIP SEMICONDUCTOR LED ASSEMBLY**

(75) Inventors: **Jerome C. Bhat**, San Jose, CA (US);
Daniel A. Steigerwald, Cupertino, CA (US);
Reena Khare, Sunnyvale, CA (US)

(73) Assignee: **Lumileds Lighting U.S., LLC**, San Jose, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/859,154**

(22) Filed: **May 15, 2001**

(65) **Prior Publication Data**

US 2001/0032985 A1 Oct. 25, 2001

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/469,657, filed on Dec. 22, 1999, now Pat. No. 6,486,499.

(51) **Int. Cl.**⁷ **H01L 27/15**; H01L 29/20

(52) **U.S. Cl.** **257/99**; 257/79; 257/81; 257/88; 257/103

(58) **Field of Search** 257/79-82, 84, 257/85, 88, 99, 103

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,593,070 A	*	7/1971	Reed	257/735
3,813,587 A		5/1974	Umeda et al.	317/235
3,947,840 A	*	3/1976	Craford et al.	257/88
4,165,474 A	*	8/1979	Myers	313/500
4,238,707 A		12/1980	Malissin et al.	315/175
4,329,625 A		5/1982	Nishizawa et al.	315/158
4,423,478 A		12/1983	Bullock et al.	363/89
4,983,884 A		1/1991	Wychulis	315/151
5,362,977 A		11/1994	Hunt et al.	257/98
5,408,120 A		4/1995	Manabe et al.	257/431

(Continued)

FOREIGN PATENT DOCUMENTS

DE	197 56856 A1	12/1997	
DE	199 21 987 A1	11/1999 H01L/33/00
EP	0 550 963 A1	7/1993	
EP	0 702414 A2	3/1996	
EP	0 772 249 A2	5/1997	
EP	0 772 249 A3	11/1998	
EP	0921577 A1	6/1999 H01L/33/00
EP	0 926 744 A2	6/1999 H01L/33/00
EP	926 744 A3	5/2000 H01L/33/00
EP	1 020 935 A2	7/2000 H01L/33/00
EP	030 377 A2	8/2000	
GB	2301934	12/1996	
GB	2 343 994	5/2000 H01L/33/00
JP	0 529 1621	11/1993	
JP	7235624	9/1995 H01L/23/48
JP	11 150 297	6/1999	
JP	11 191 641	7/1999	
JP	11 274568	10/1999 H01L/33/00

OTHER PUBLICATIONS

Roger Maxwell, "LED or Lamp Flasher: Minimum parts counting Designed for 3V battery operation", http://www.ee.washington.edu/circuit_archive/circuits.

(Continued)

Primary Examiner—Nathan J. Flynn

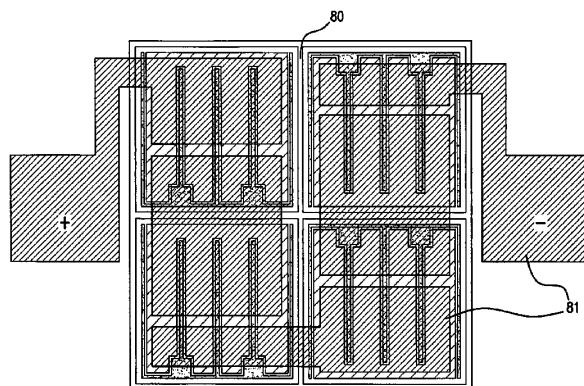
Assistant Examiner—Johannes Mondt

(74) *Attorney, Agent, or Firm*—Patent Law Group LLP

(57) **ABSTRACT**

A light emitting device includes several LEDs, mounted on a shared submount, and coupled to circuitry formed on the submount. The LEDs can be of the III-Nitride type. The architecture of the LEDs can be either inverted, or non-inverted. Inverted LEDs offer improved light generation. The LEDs may emit light of the same wavelength or different wavelengths. The circuitry can couple the LEDs in a combination of series and parallel, and can be switchable between various configurations. Other circuitry can include photosensitive devices for feedback and control of the intensity of the emitted light, or an oscillator, strobing the LEDs.

36 Claims, 34 Drawing Sheets



U.S. PATENT DOCUMENTS

5,410,159 A	4/1995	Sugawara et al.	257/13
5,461,425 A	10/1995	Fowler et al.	348/294
5,475,241 A *	12/1995	Harrah et al.	257/99
5,557,115 A	9/1996	Shakuda	257/81
5,563,422 A	10/1996	Nakamura et al.	257/13
5,621,225 A *	4/1997	Shieh et al.	257/81
5,744,829 A	4/1998	Murasato et al.	257/94
5,862,167 A	1/1999	Sassa et al.	372/45
5,886,401 A	3/1999	Liu	257/678
5,914,501 A	6/1999	Antle et al.	257/99
5,955,747 A *	9/1999	Ogihara et al.	257/88
5,998,232 A	12/1999	Maruska	438/46
6,016,038 A	1/2000	Mueller et al.	315/291
RE36,747 E	6/2000	Manabe et al.	257/431
6,081,540 A	6/2000	Nakatsu	372/45
6,091,085 A	7/2000	Lester	257/98
6,121,127 A	9/2000	Shibata et al.	438/604
6,133,589 A	10/2000	Krames et al.	257/103
6,150,774 A	11/2000	Mueller et al.	315/291
6,169,294 B1	1/2001	Biing-Jye et al.	257/79
6,333,522 B1 *	12/2001	Inoue et al.	257/99
6,384,429 B1 *	5/2002	Ogihara et al.	257/88

OTHER PUBLICATIONS

G. J. Sun and K. H. Chae, "Properties of 2,3-butanedione and 1-phenyl-1,2-propanedione As New Photosensitizers For Visible Light Cured Dental Resin Composites", *Polymer*, vol. 41, pp. 6205-6212 (2000).
 Evans et al., "Edge-Emitting Quantum Well Heterostructure Laser Diodes with Auxiliary Native-Oxide Vertical Cavity Confinement," *Applied Physics Letters*, 67(1995) Nov. 20, No. 21, pp. 3168-3170.

Han, H. et al.: "Electroplated Solder Joints for Optoelectronic Applications" *Electronic Components & Technology*, 1996, pp. 963-966, XP000646645.

"Barrier Layer in the metallisation of Semiconductor Diode Lasers" *Research Disclosure*, Kenneth Mason Publications, Hampshire, 1994, No. 360, p. 179, XP000446545, ISSN: 0374-4353.

Krames et al., "High-Power Truncated-Inverted-Pyramid (Al_xGa_{1-x}) 0.5In_{0.5}P/GaP Light-Emitting Diodes Exhibiting >50% External Quantum Efficiency", *Applied Physics Letter*, vol. 75, No. 16, Oct. 18, 1999, pp. 2365-2367.

Mensz, P.M. et al.: "In_xGa_{1-x}N/Al_yGa_{1-y}N violet light emitting diodes with reflective p-contacts for high single sided light extraction" *Electronics Letters*, GB, IEE Stevenage, vol. 33, No. 24, Nov. 20, 1997, pp. 2066-2068, XP000734311, ISSN: 0013-5194.

Tan, Q. et al.: "Soldering technology for Optoelectronic Packaging" *Electronic Components & Technology*, 1996, pp. 26-36, XP000646646.

Sugawara, H. et al, "Emission Properties of InGaAlP, Visible Light-Emitting Diodes Employing a Multi-Quantum-Well Active Layer", *Jpn. J. Appl. Phys.*, vol. 33 (1994) Pt. 1, No. 10, Oct. 1994, pp. 5784-5787.

Chang, S. J., et al, "AlGaInP multi-quantum well light-emitting diodes", *IEE Proc.-Optoelectron*, vol. 144, No. 6, Dec. 1997, pp. 405-409.

Benisty, H., "Impact of Planar Microcavity Effects on Light Extraction-Part I: Basic Concepts and Analytical Trends", *IEE Journal of Quantum Electronics*, vol. 34, No. 9, Sep. 1998, pp. 1612-1631.

* cited by examiner

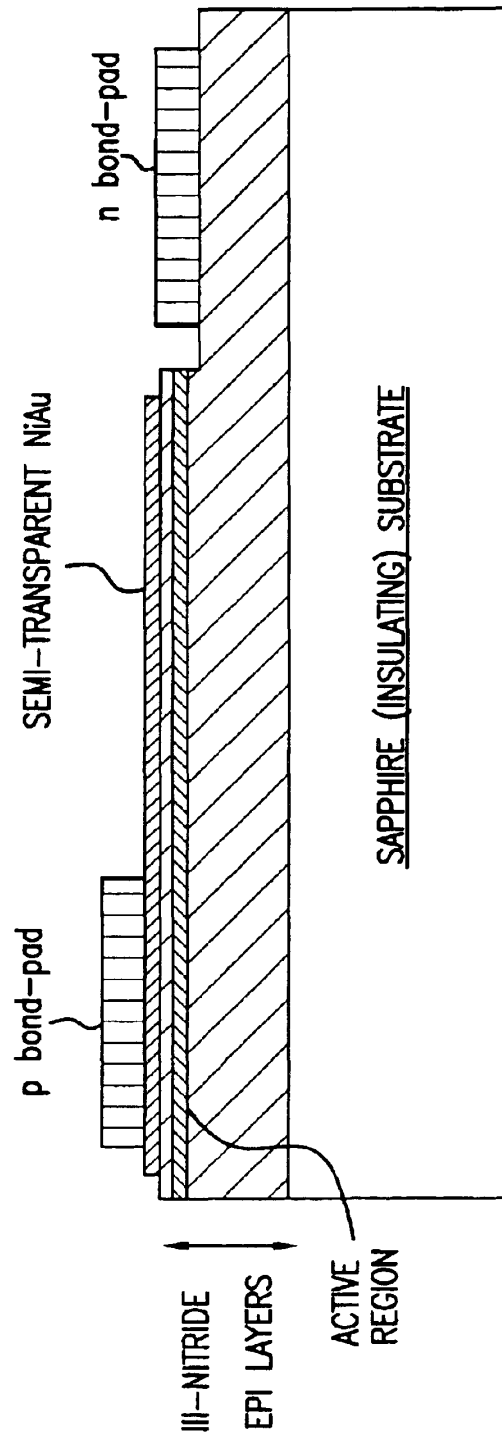


FIG. 1
PRIOR ART

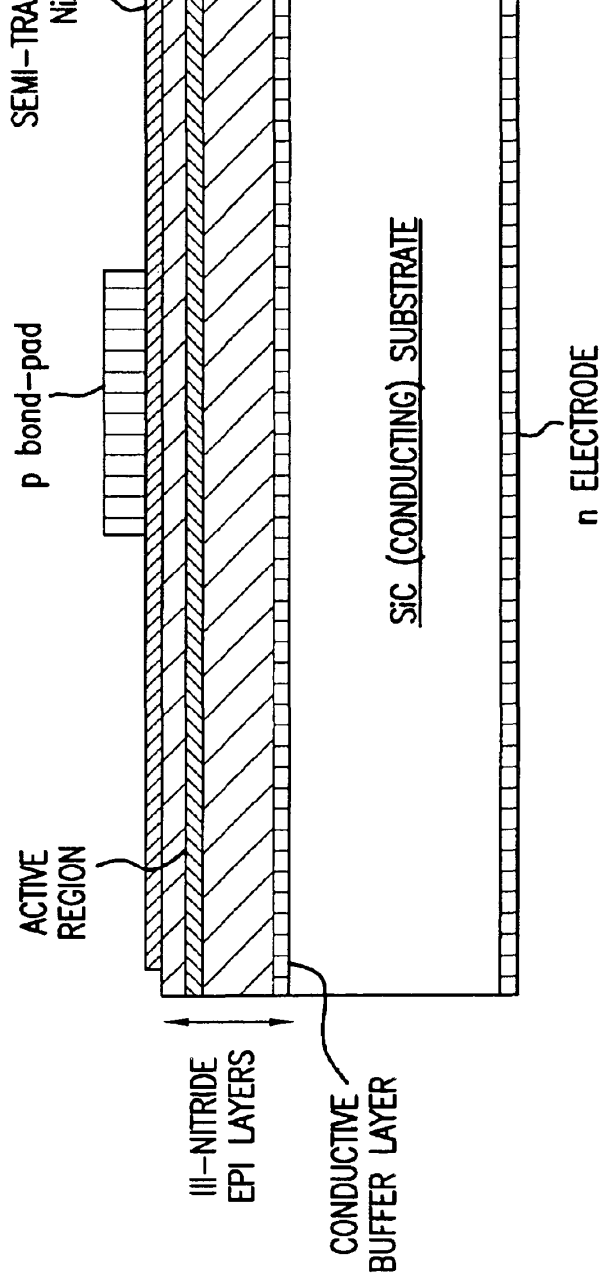


FIG.2

PRIOR ART

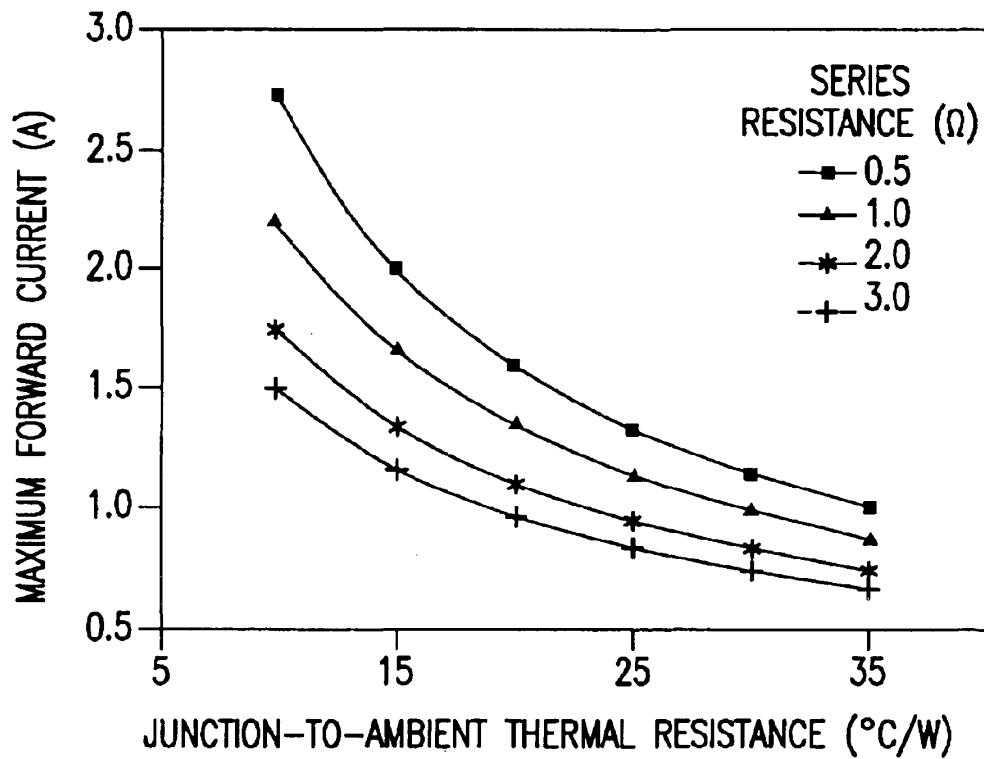


FIG.3

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.