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United States Patent [19]

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Kish et al.

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[54] **WAFER BONDING OF LIGHT EMITTING DIODE LAYERS**

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[51] Int. Cl.⁵ H01L 21/20

[52] U.S. Cl. 437/127; 437/129; 437/130; 437/117

[58] Field of Search 437/127, 129, 130, 905, 437/974, 117, 229; 148/DIG. 135

[56] **References Cited****U.S. PATENT DOCUMENTS**

4,771,016	9/1988	Bajor et al.	148/DIG. 135
4,775,645	10/1988	Kurata et al.	437/905
4,846,931	7/1989	Gmitter et al.	156/633
4,864,369	9/1989	Snyder et al.	357/17
4,864,371	9/1989	Steranka	357/17
4,883,561	11/1989	Gmitter et al.	156/633
4,902,356	2/1990	Noguchi et al.	437/127
4,921,817	5/1990	Noguchi	437/127
4,971,925	11/1990	Alexander et al.	148/DIG. 135
4,992,837	2/1991	Sakai et al.	357/17
5,008,718	4/1991	Fletcher et al.	357/17
5,087,585	2/1992	Hayashi	437/974
5,110,748	5/1992	Sarma	437/974
5,135,877	8/1992	Albergo et al.	437/229
5,153,889	10/1992	Sugawara et al.	372/45
5,244,817	9/1993	Hawkins et al.	148/DIG. 135

OTHER PUBLICATIONS

Dudley, J. J., et al., "144° C. operation of 1.3 μ m In-GaAsP vertical cavity lasers on GaAs substrates", *Appl. Phys. Lett.*, 61 (26), Dec. 28, 1992, pp. 3095-3097.

Ishiguro, Hisanori et al., "High efficient GaAlAs light-

-emitting diodes of 660 nm with a double heterostructure on a GaAlAs substrates", *Appl. Phys. Lett.*, 43 (11), Dec. 1, 1983, pp. 1034-1036.

Pollentier, I. et al., "Epitaxial Lift-off GaAs LEDs to Si for Fabrication of Opto-Electronic Integrated Circuits", *Electronics Letters*, vol. 36, No. 3, Feb. 1, 1990, pp. 193-194.

Schnitzer, I. et al., "Ultrahigh spontaneous emission quantum efficiency, 99.7% internally and 72% externally, from AlGaAs/GaAs/AlGaAs double heterostructures", *Appl. Phys. Lett.*, 63 (3), Jan. 11, 1993, pp. 131-133.

Sugawara, H. et al., "High-efficiency InGaAlP/GaAs visible light-emitting diodes", *Appl. Phys. Lett.*, 58 (10), Mar. 11, 1991, pp. 1010-1012.

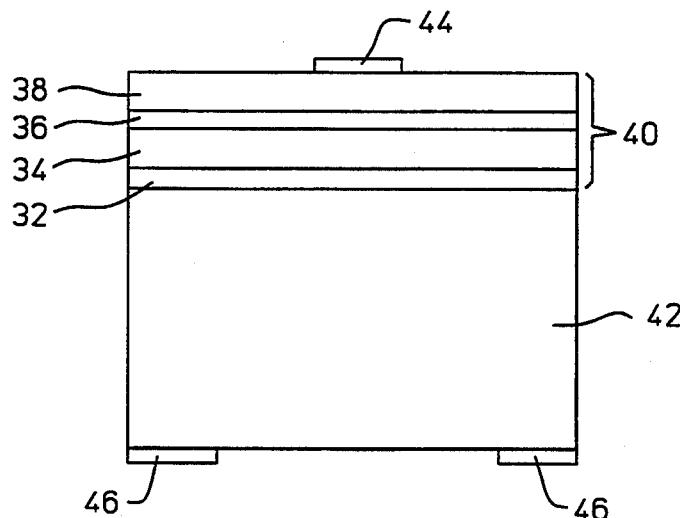
Primary Examiner—Tom Thomas

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[57] **ABSTRACT**

A method of forming a light emitting diode (LED) includes providing a temporary growth substrate that is selected for compatibility with fabricating LED layers having desired mechanical characteristics. For example, lattice matching is an important consideration. LED layers are then grown on the temporary growth substrate. High crystal quality is thereby achieved, whereafter the temporary growth substrate can be removed. A second substrate is bonded to the LED layers utilizing a wafer bonding technique. The second substrate is selected for optical properties, rather than mechanical properties. Preferably, the second substrate is optically transparent and electrically conductive and the wafer bonding technique is carried out to achieve a low resistance interface between the second substrate and the LED layers. Wafer bonding can also be carried out to provide passivation or light-reflection or to define current flow.

29 Claims, 13 Drawing Sheets



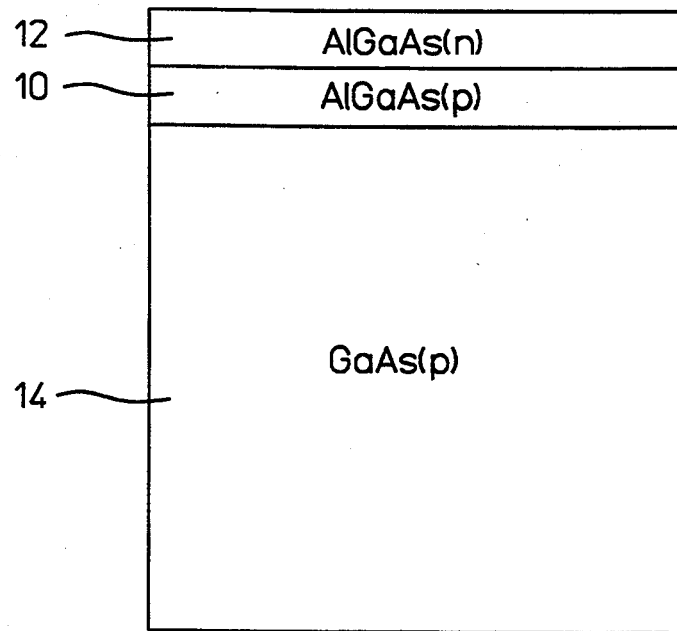


FIG. 1 (PRIOR ART)

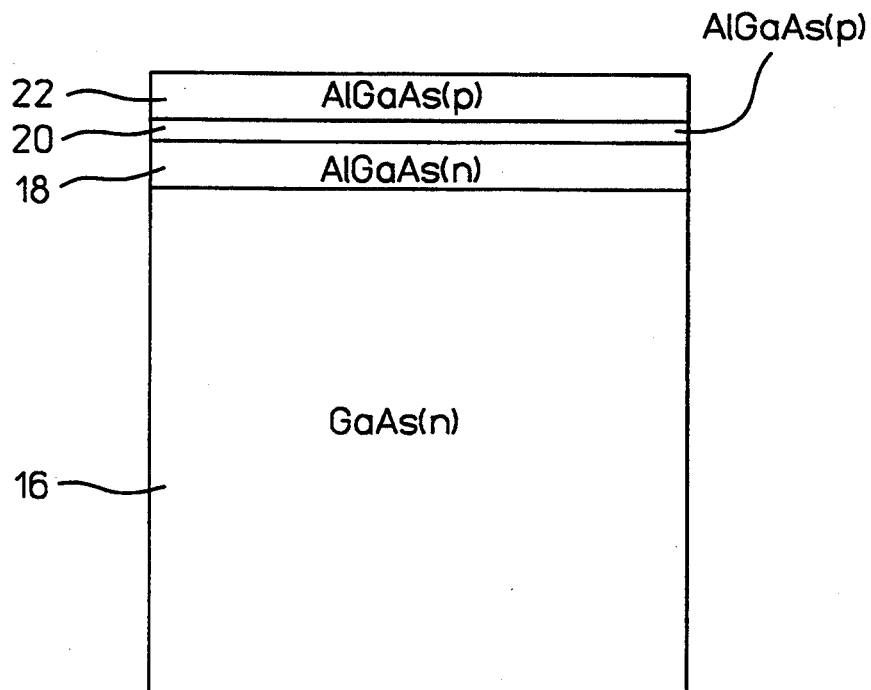


FIG. 2 (PRIOR ART)

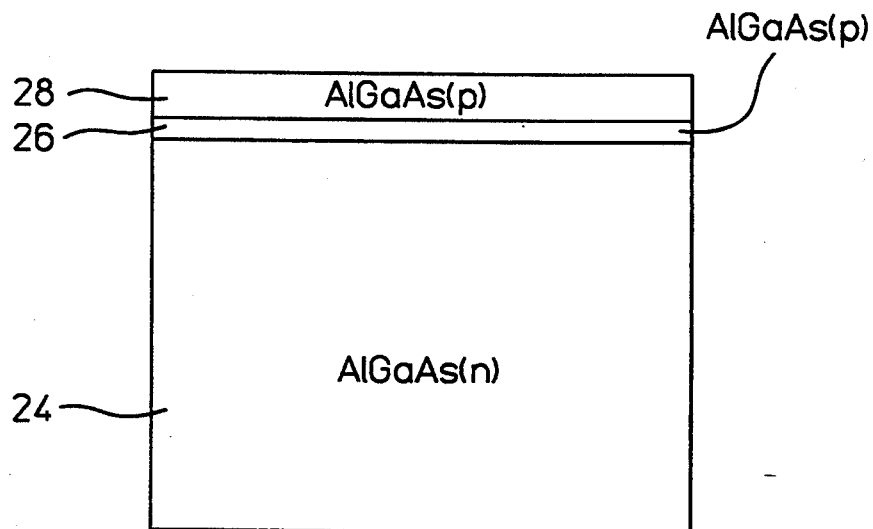


FIG. 3 (PRIOR ART)

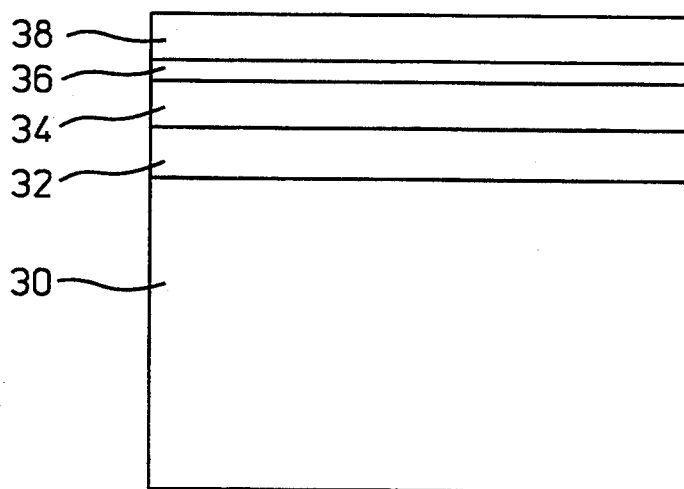
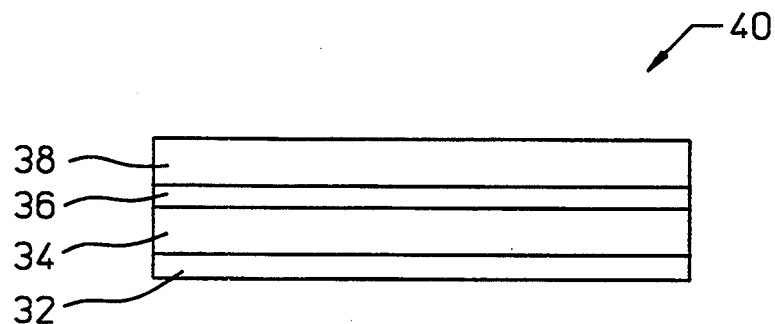
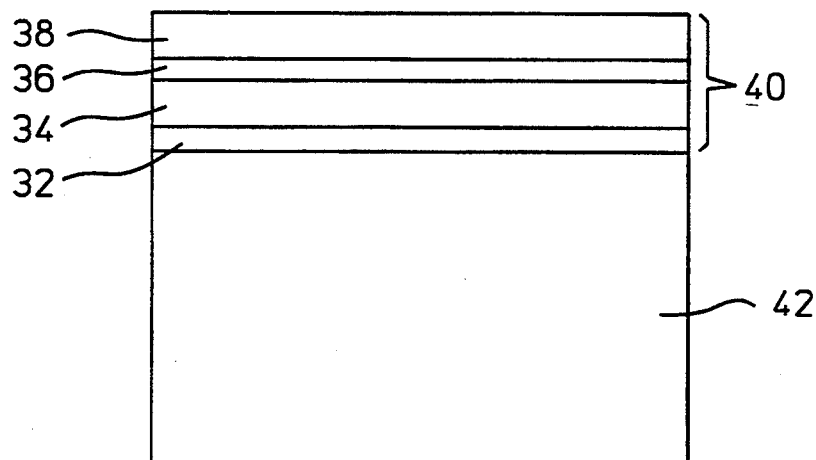
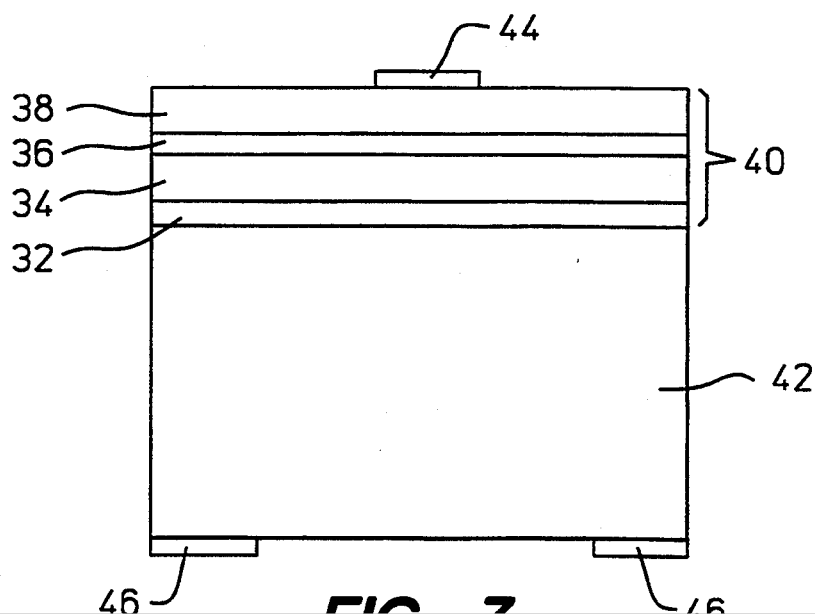
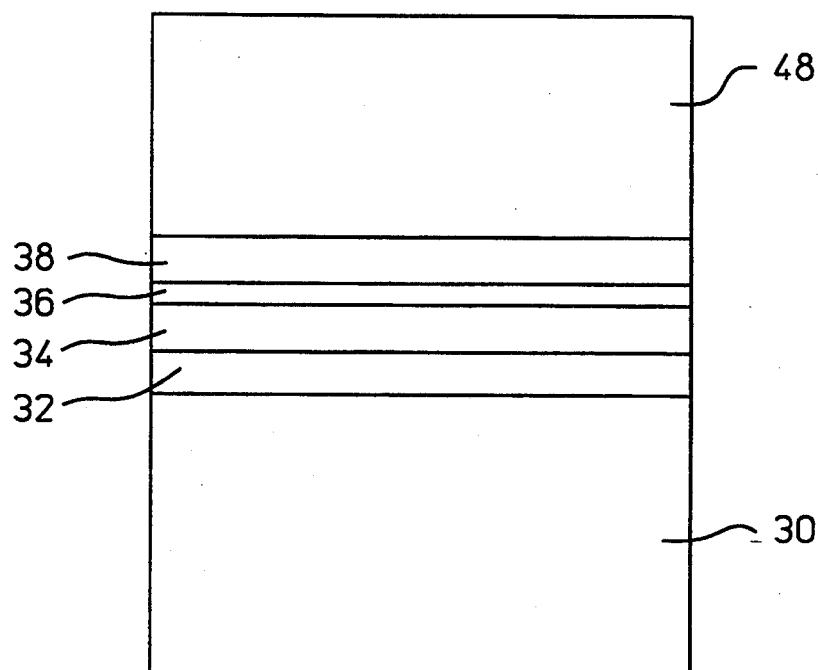
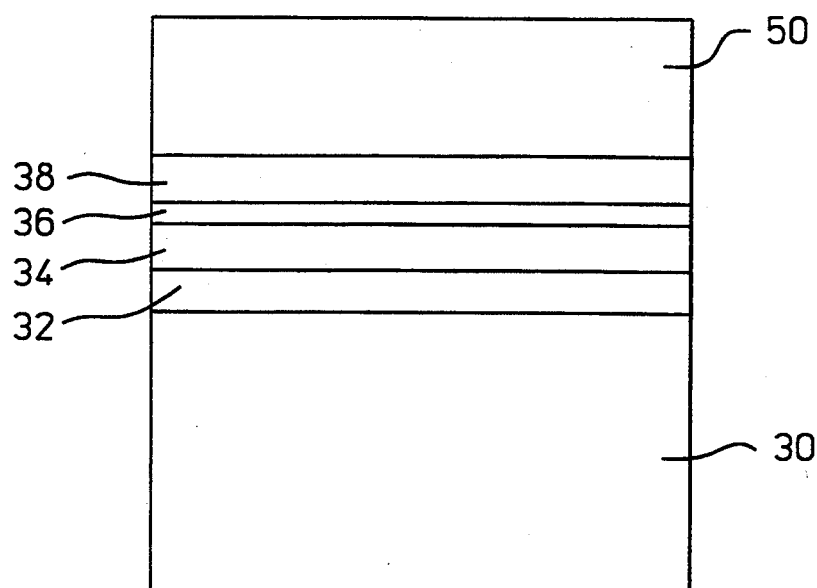


FIG. 4

**FIG. 5****FIG. 6****FIG. 7**

**FIG. 8****FIG. 9**

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