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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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- [73] Assignee: **Hewlett-Packard Company**, Palo Alto, Calif.
- [21] Appl. No.: **36,532**
- [22] Filed: **Mar. 19, 1993**
- [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 μm 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.

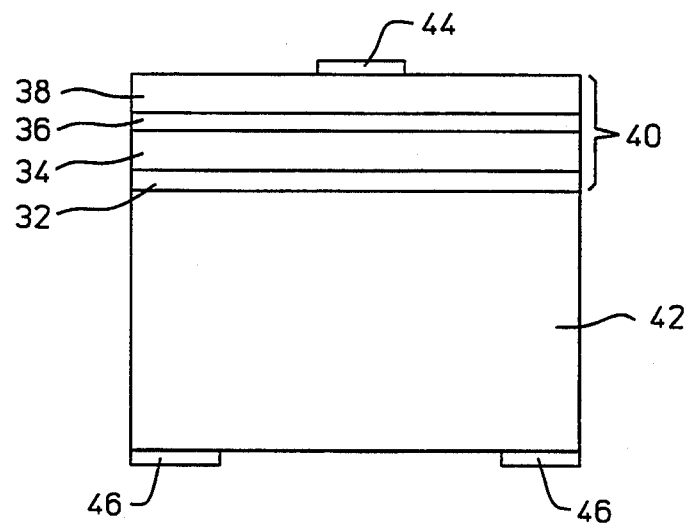
Sugawara, H. et al., "High-efficiency InGaAlP/GaAs visible light-emitting diodes", *Appl. Phys. Lett.*, 58 (10), Mar. 11, 1991, pp. 1010-1012.

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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



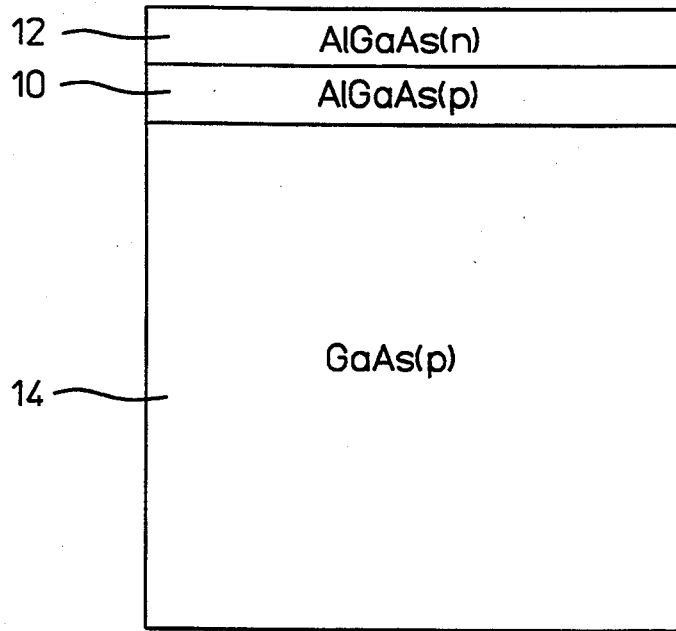


FIG. 1 (PRIOR ART)

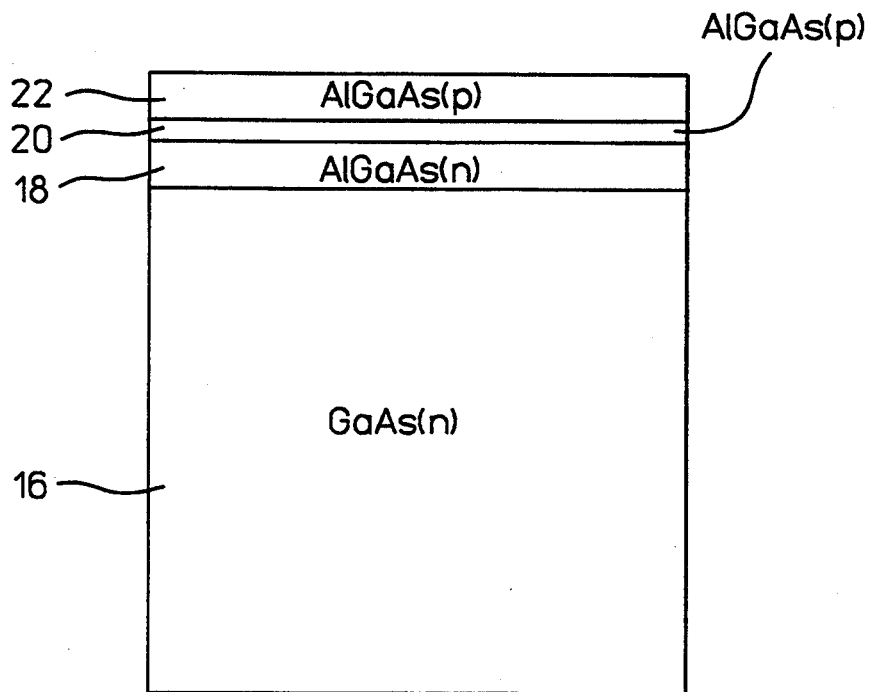


FIG. 2 (PRIOR ART)

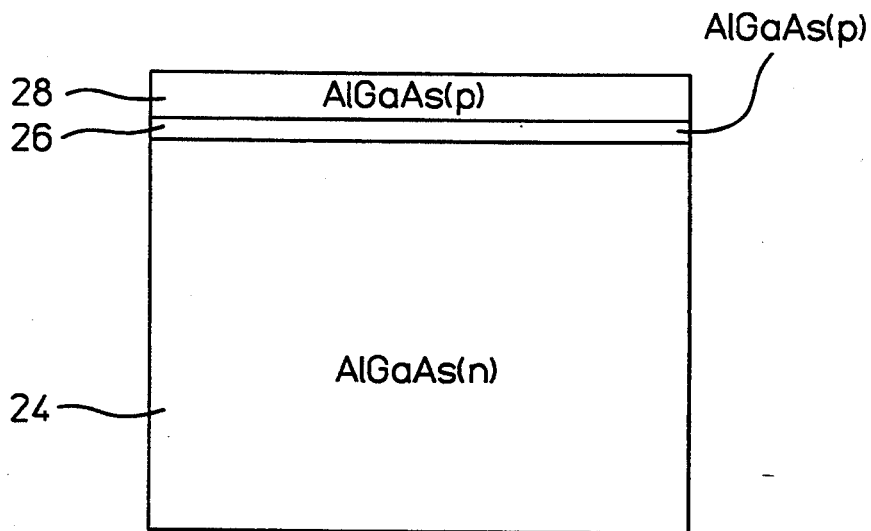


FIG. 3 (PRIOR ART)

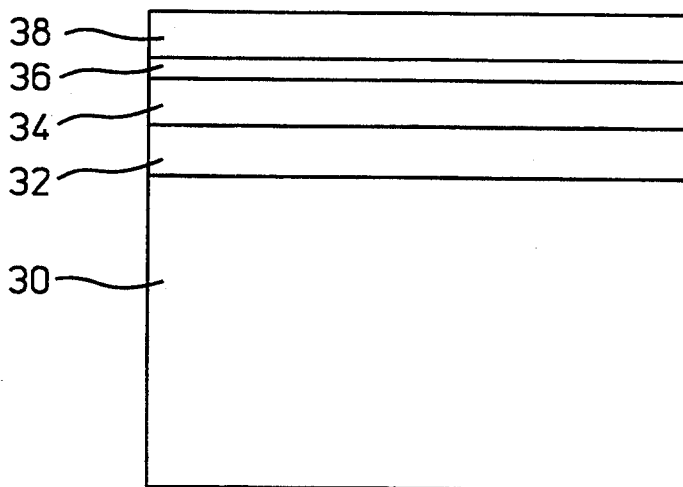


FIG. 4

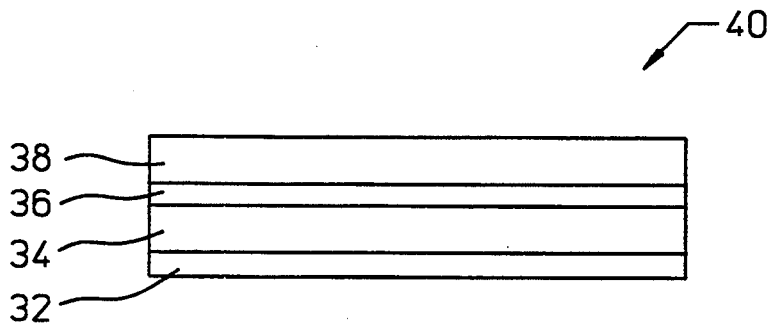


FIG. 5

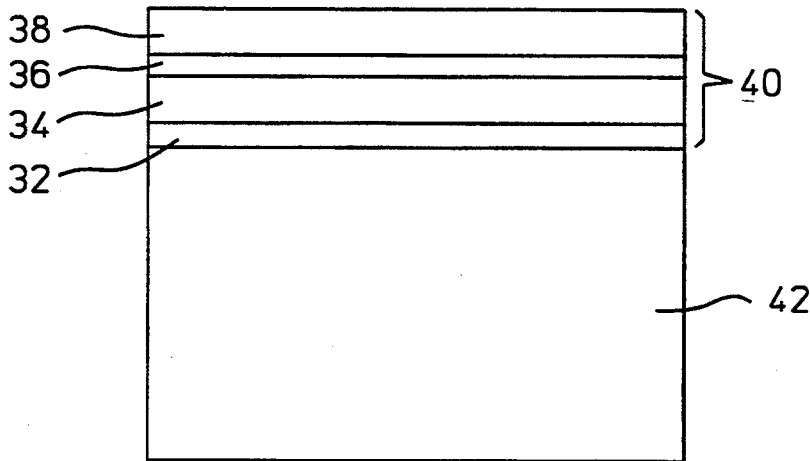


FIG. 6

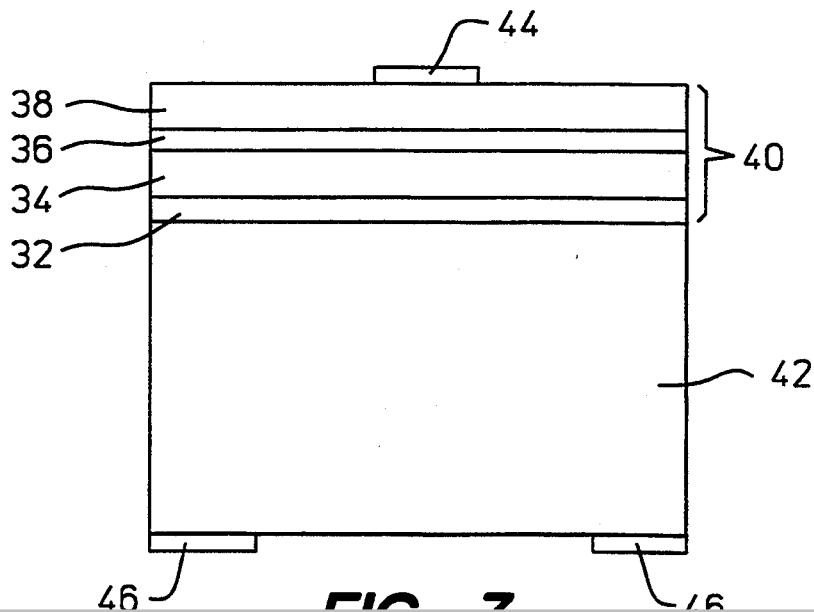


FIG. 7

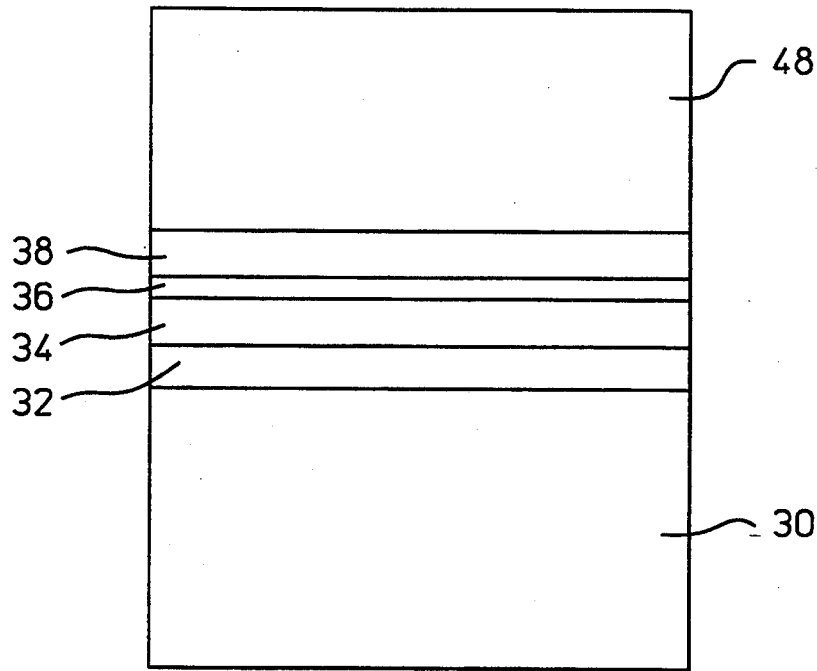


FIG. 8

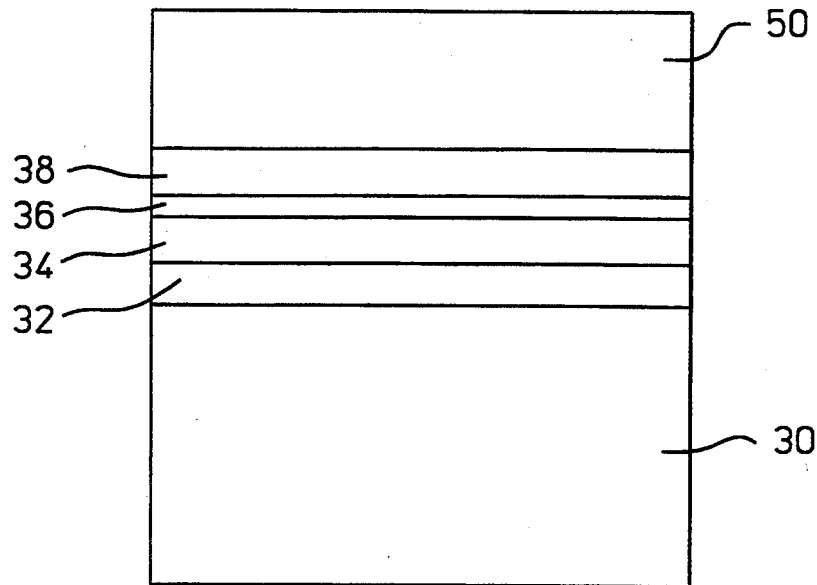


FIG. 9

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