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Parikh et al.

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(54) **III-N DEVICE STRUCTURES AND METHODS**

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USPC 257/79, 190, 192, 194, 778, E27.012, 257/E29.249, E29.317, E21.407, E21.451; 438/167, 172, 571, 667, 712
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,300,091 A 11/1981 Schade, Jr.
4,532,439 A 7/1985 Koike
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1748320 3/2006
CN 101107713 1/2008
(Continued)

OTHER PUBLICATIONS

Authorized officer Chung Keun Lee, International Search Report and Written Opinion in PCT/US2008/076030, mailed Mar. 23, 2009, 10 pages.
(Continued)

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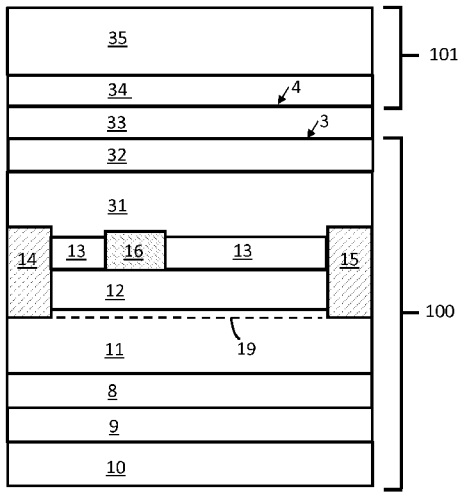
(57) **ABSTRACT**

A III-N device is described with a III-N layer, an electrode thereon, a passivation layer adjacent the III-N layer and electrode, a thick insulating layer adjacent the passivation layer and electrode, a high thermal conductivity carrier capable of transferring substantial heat away from the III-N device, and a bonding layer between the thick insulating layer and the carrier. The bonding layer attaches the thick insulating layer to the carrier. The thick insulating layer can have a precisely controlled thickness and be thermally conductive.

22 Claims, 13 Drawing Sheets