Activation of P-Type Layers of Tunnel Junctions in Micro-LEDs
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BACKGROUND

P-type gallium nitride (p-GaN) is difficult to contact electrically and has a low hole concentration and mobility in conventional commercial III-nitride LEDs. This means that p-GaN cannot be used as a current spreading layer and that traditional p-contacts will add significant voltage to devices. Despite these inherent problems, all commercial light emitting devices utilize traditional p-contacts and materials other than p-GaN for current spreading, which typically involves a high barrier for tunneling. Unfortunately, current approaches to reduce the tunneling barrier are associated with losses, either in terms of voltage or resistance increases, or optical losses in the final device performance. These penalties exist even in smaller LED devices such as mini-LEDs and micro-LEDs.

DESCRIPTION

Researchers at the University of California, Santa Barbara have fabricated low forward voltage micro-LEDs with an epitaxial tunnel junction comprised of p+GaN, an In$_{x}$Al$_{y}$Ga$_{2-x-y}$N insertion layer, and n+GaN layers grown using metalorganic chemical vapor deposition (MOCVD). The In$_{x}$Al$_{y}$Ga$_{2-x-y}$N insertion layer offers a smaller energy bandgap than the GaN layers, which works to reduce the depletion width of the tunnel junctions and increase the tunnel probability. Tunnel junction micro-LEDs with an n-type and p-type In$_{x}$Al$_{y}$Ga$_{2-x-y}$N insertion layer demonstrated a very stable low forward voltage at 20A cm$^{-2}$. Therefore, fabrication of micro-LEDs with low forward voltage is achieved, increasing the potential for next-generation display applications.

ADVANTAGES

▶ Low forward voltage
▶ Reduced tunnel junction depletion width
▶ Increased tunnel probability

APPLICATIONS

▶ Micro-LEDs

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

▶ Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
▶ High Efficiency LED with Optimized Photonic Crystal Extractor
▶ Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
▶ Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
▶ Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
▶ Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
▶ Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
▶ Defect Reduction in GaN films using in-situ SiNx Nanomask
▶ Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
▶ Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
▶ Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
▶ Phosphor-Free White Light Source
▶ Low Temperature Deposition of Magnesium Doped Nitride Films
▶ Transparent Mirrorless (TML) LEDs
▶ Improved GaN Substrates Prepared with Ammonothermal Growth
Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures

Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD