



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

Tech ID: 32270 / UC Case 2021-551-0

### 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  $\text{In}_x\text{Al}_y\text{Ga}_z\text{N}$  insertion layer, and n+GaN layers grown using metalorganic chemical vapor deposition (MOCVD). The  $\text{In}_x\text{Al}_y\text{Ga}_z\text{N}$  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  $\text{In}_x\text{Al}_y\text{Ga}_z\text{N}$  insertion layer demonstrated a very stable low forward voltage at  $20\text{A cm}^{-2}$ . 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

### PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Published Application	20230307579	09/28/2023	2021-551

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### OTHER INFORMATION

#### KEYWORDS

p+GaN, n+GaN, MOCVD,  
micro-LED, tunnel junction,  
forward voltage

#### CATEGORIZED AS

- ▶ [Energy](#)
- ▶ [Lighting](#)
- ▶ [Semiconductors](#)
- ▶ [Design and Fabrication](#)

#### RELATED CASES

2021-551-0

## RELATED MATERIALS

- ▶ Fully transparent metal-organic chemical vapor deposition-grown cascaded InGaN micro-light-emitting diodes with independent junction control - 06/25/2021

## ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- ▶ Eliminating Misfit Dislocations with In-Situ Compliant Substrate Formation
- ▶ III-Nitride-Based Vertical Cavity Surface Emitting Laser (VCSEL) with a Dielectric P-Side Lens
- ▶ Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
- ▶ Methods to Produce and Recycle Substates for III-Nitride Materials with Electrochemical Etching
- ▶ III-Nitride Tunnel Junction with Modified Interface
- ▶ Improved Reliability & Enhanced Performance of III-Nitride Tunnel Junction Optoelectronic Devices
- ▶ (In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- ▶ Thermally Stable, Laser-Driven White Lighting Device
- ▶ III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- ▶ Novel Multilayer Structure for High-Efficiency UV and Far-UV Light-Emitting Devices
- ▶ A Method To Lift-Off Nitride Materials With Electrochemical Etch
- ▶ High-Intensity Solid State White Laser Diode
- ▶ Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact
- ▶ Epitaxial Light Control Features in Light Emitting Diodes
- ▶ High-Efficiency Vertical Cavity Surface Emitting Laser Fabrication
- ▶ A Wafer-Scale, Low Defect Density Strain Relaxed Template for III-Nitride-Based High Efficiency and High-Power Devices
- ▶ High-Efficiency and High-Power III-Nitride Devices Grown on or Above a Strain Relaxed Template
- ▶ III-Nitride Based VCSEL with Curved Mirror on P-Side of the Aperture

