Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)

Tech ID: 24434 / UC Case 2010-183-0

**BRIEF DESCRIPTION**
UC Santa Barbara researchers have improved the performance of GaN LEDs through the addition of ZnO layers to the LED’s surfaces.

**BACKGROUND**
To improve the light extraction efficiency of LEDs, transparent conductive oxides (TCOs) with high refractive indices — such as indium-tin-oxide (ITO), zinc oxide (ZnO), aluminum-doped-zinc-oxide (AZO) — are widely used. Films of these materials increase the probability of light escaping the LED through the TCO, thus increasing overall light output. ITO, however, is cost prohibitive, making zinc oxide films a better choice for commercial scalability.

**DESCRIPTION**
UC Santa Barbara researchers have improved the performance of GaN LEDs through the addition of ZnO layers to the LED’s surfaces. These layers can improve the light extraction, heat dissipation, and current distribution of the device. The method of depositing ZnO by a low-temperature, aqueous route is low-cost and flexible, and can be used before or after the LED fabrication processing, resulting in low-cost, high-light-output GaN LED devices.

**ADVANTAGES**
- Increased light output
- Low-cost fabrication

**APPLICATIONS**
- LEDs
- Solar cells
- GaN-based devices

**PATENT STATUS**

<table>
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<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
<th>Dated</th>
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<tr>
<td>United States Of America</td>
<td>Issued Patent</td>
<td>8,637,334</td>
<td>01/28/2014</td>
<td>2010-183</td>
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**RELATED CASES**
2010-183-0

**ADDITIONAL TECHNOLOGIES BY THESE INVENTORS**
- Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
- 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
- Eliminating Misfit Dislocations with In-Situ Compliant Substrate Formation
- III-Nitride-Based Devices Grown With Relaxed Active Region
- 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

**CONTACT**
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- Low Temperature Deposition of Magnesium Doped Nitride Films
- Transparent Mirrorless (TML) LEDs
- Improved GaN Substrates Prepared with Ammonothermal Growth
- Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
- Size-Independent Forward Voltage Micro-LED with an Epitaxial Junction
- Method for Enhancing Growth of Semipolar Nitride Devices
- III-Nitride Tunnel Junction with Modified Interface
- Growth of Polyhedron-Shaped Gallium Nitride Bulk Crystals
- Nonpolar III-Nitride LEDs With Long Wavelength Emission
- Increased Light Extraction with Multistep Deposition of ZnO on GaN
- Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of optically Pumped and Electrically Injected III-Nitride LEDs
- Selective-Area Mesoporous Semiconductors And Devices For Optoelectronic And Photonic Applications
- High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
- Method for Growing High-Quality Group III-Nitride Crystals
- Controlled Photoelectrochemical (PEC) Etching by Modification of Local Electrochemical Potential of Semiconductor Structure
- Oxyfluoride Phosphors for Use in White Light LEDs
- Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- (In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- Thermally Stable, Laser-Driven White Lighting Device
- MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
- Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
- Highly Compact, High-Index Dielectric Nanostructures for Deep-Ultraviolet Devices
- Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDS
- Methods for Fabricating III-Nitride Tunnel Junction Devices
- Low-Droop LED Structure on GaN Semi-polar Substrates
- Contact Architectures for Tunnel Junction Devices
- Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
- Photoelectrochemical Etching Of P-Type Semiconductor Heterostructures
- Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance
- III-Nitride-Based Devices Grown On Thin Template On Thermally Decomposed Material
- Growth of Semipolar III-V Nitride Films with Lower Defect Density
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- Improved Manufacturing of Solid State Lasers via Patterning of Photonic Crystals
- High Efficiency III-Nitride Devices with Smooth Relaxed InGaN Buffer and Strain Compliant Template
- Multifaceted III-Nitride Surface-Emitting Laser
- Tunable White Light Based on Polarization-Sensitive LEDs
- Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
- Growth of High-Performance M-plane GaN Optical Devices
- Packaging Technique for the Fabrication of Polarized Light Emitting Diodes
- Improved Anisotropic Strain Control in Semipolar Nitride Devices
- High Light Extraction Efficiency III-Nitride LED
- III-V Nitride Device Structures on Patterned Substrates
- Activation of P-Type Layers of Tunnel Junctions in Micro-LEDs
- Method for Increasing GaN Substrate Area in Nitride Devices
- Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact
- Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
- GaN-Based Thermoelectric Device for Micro-Power Generation
- Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
- LED Device Structures with Minimized Light Re-Absorption
- Growth of Planar Semi-Polar Gallium Nitride
- Nonpolar (Al, B, In, Ga)N Quantum Well Design
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
- III-Nitride Based VCSEL with Curved Mirror on P-Side of the Aperture
- Enhancing Growth of Semipolar (AlIn,Ga,B)N Films via MOCVD