High Light Extraction Efficiency III-Nitride LED
Tech ID: 25553 / UC Case 2008-277-0

**BRIEF DESCRIPTION**
A III-nitride light emitting diode (LED) with increased light extraction from having at least one textured surface of a semipolar or nonpolar plane of a III-nitride layer of the LED.

**BACKGROUND**
While the advent of high-quality freestanding GaN substrates has led to the development of high-performance nonpolar and semipolar LEDs, there is plenty of room for improving the light extraction efficiency. The lack of means for surface roughening has become a major hurdle for nonpolar and semipolar LEDs to achieve higher extraction efficiency and hence higher overall efficiency, and therefore improved roughening techniques are needed to address this issue.

**DESCRIPTION**
Researchers at the University of California, Santa Barbara have developed a III-nitride light emitting diode (LED) with increased light extraction from having at least one textured surface of a semipolar or nonpolar plane of a III-nitride layer of the LED. The texturing may be performed by plasma-assisted chemical etching, photolithography followed by etching, or nano-imprinting followed by etching.

**ADVANTAGES**
▶ Increased light extraction efficiency and output power
▶ More straightforward than other light extraction enhancement techniques (such as using a photonic crystal)
▶ Applicable to all nitride semiconductor surfaces regardless of crystal structure

**APPLICATIONS**
▶ LEDs

**PATENT STATUS**

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<th>Type</th>
<th>Number</th>
<th>Dated</th>
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<td>United States Of America</td>
<td>Issued Patent</td>
<td>9,040,326</td>
<td>05/26/2015</td>
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<td>8,114,698</td>
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**RELATED CASES**
2008-277-0

**ADDITIONAL TECHNOLOGIES BY THESE INVENTORS**
▶ Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
▶ Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
▶ Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
▶ Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
▶ III-Nitride-Based Devices Grown With Relaxed Active Region
▶ Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
▶ 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
▶ 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
Improved Fabrication of Nonpolar InGaN Thin Films, Heterostructures, and Devices
Growth of High-Quality, Thick, Non-Polar M-Plane GaN Films
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 Patternning of Photonic Crystals
High Efficiency III-Nitride Devices with Smooth Relaxed InGaN Buffer and Strain Compliant Template
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
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 Patternning
LED Device Structures with Minimized Light Re-Absorption
Growth of Planar Semi-Polar Gallium Nitride
Nonpolar (Al, 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 (Al,In,Ga,B)N Films via MOCVD