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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<td>United States Of America</td>
<td>Issued Patent</td>
<td>9,040,326</td>
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<td>8,114,698</td>
<td>02/14/2012</td>
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RELATED CASES
2008-277-0

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
- Edge-Emitting Laser Diode with Via-Activated Tunnel Junction Contact
- Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
- Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
- Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Liftoff Technique
- Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- Gallium-containing MicroLEDs for Displays
- High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
- 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
Volumetric Hole Injection with Intentional V-Defects
Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure
Low Temperature Deposition of Magnesium Doped Nitride Films
Transparent Mirrorless (TML) LEDs
Improved GaN Substrates Prepared with Ammonothermal Growth
Laser Diode With Tunnel Junction Contact Surface Grating
Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
Method for Growing Self-Assembled Quantum Dot Lattices
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
Near-Infrared, Flip-Chip, TCO-Clad, InGaN Quantum Dot Laser Diode
Incorporating Temperature-Sensitive Layers in III-N Devices
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
MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
Al, In,Ga, B)N Device Structures
Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDS
Methods for Fabricating III-Nitride Tunnel Junction Devices
3D Hole Injectors for InAlGaN Light-Emitting Diodes
Formation of Transparent Integrated MicroLED Displays
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
Growth of Semipolar III-V Nitride Films with Lower Defect Density
III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
In-Situ Methods Of Preventing Interfacial Impurities And Dry Etch-Induced Damage In Regrown III-Nitride Structures
Enhanced Hole Injection by P-Type Active Region and Lateral Injection in InAlGaN LEDs
Improved Manufacturing of Solid State Lasers via Patternning of Photonic Crystals
Solid Solution Phosphors for Use in Solid State White Lighting Applications
Multifaceted III-Nitride Surface-Emitting Laser
Tunable White Light Based on Polarization-Sensitive LEDs
Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
III-Nitride VCSEL with a High Indium Content Active Region
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

Photoelectrochemical Etching for Chip Shaping Of LEDs

III-V Nitride Device Structures on Patterned Substrates

Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration

Method for Increasing GaN Substrate Area in Nitride Devices

Burying Impurities And Defects In Regrown III-Nitride Structures

Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy

Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate

GaN-Based Thermoelectric Device for Micro-Power Generation

Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning

Improved Manufacturing of Semiconductor Lasers

LED Device Structures with Minimized Light Re-Absorption

Improved Light Extraction with Geometrically Tuned LED Arrays

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

Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)

Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping

Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures

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