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>9,040,326</td>
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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) Lifttoff Technique
- Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- Retaining Injection Efficiency and Optical Properties of Laser Diodes with Built-in Polarization Fields
- Gallium-containing MicroLEDs for Displays
- High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector

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OTHER INFORMATION
KEYWORDS
indssl, indled, LED, III-nitride

CATEGORIZED AS
- Engineering
- Energy
  - Lighting
- Other
- Semiconductors
  - Design and Fabrication

RELATED CASES
2008-277-0
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 SiN$_x$ 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

Distributed Feedback Laser with Transparent Conducting Oxide Grating

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

Fabricating III-Nitride Semipolar and Nonpolar Lasers on Scalable Foreign Substrate to Large Area

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,AI)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

(AI, 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

Planar, Nonpolar M-Plane III-Nitride Films Grown on Miscut Substrates

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 Patterned 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
- Fabricating Scalable, High Angle Inclination Semipolar Substrates
- 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 Nanostructures
- Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD