High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices

Tech ID: 25552 / UC Case 2007-317-0

BRIEF DESCRIPTION
An (Al, Ga, In)N light emitting device in which high light generation efficiency occurs by fabricating the device using non-polar or semi-polar GaN crystals.

BACKGROUND
The thickness of the quantum well (QW) in conventional GaN-based LEDs and LDs is only around 2-5 nm, due to the c-axis oriented GaN crystals which limit the thickness of the QW that can be achieved without losing efficiency. Conventional LEDs also utilize mirrors to increase the light output power from the front side of the LED. Reflected emissions are partially re-absorbed by the LED, further reducing the output power and efficiency of the LED.

DESCRIPTION
Researchers at UC Santa Barbara have developed an (Al, Ga, In)N light emitting device in which high light generation efficiency occurs by fabricating the device using non-polar or semi-polar GaN crystals. This geometry allows for a QW layer larger than 5 nm with low piezoelectric effects so that higher efficiencies at higher current densities can be achieved. The device also minimizes internal reflections within the LED by eliminating mirrors and/or mirrored surfaces, in order to minimize re-absorption of light by the emitting or active layer of the LED.

ADVANTAGES
▶ More effective generation of polarized light than c-plane devices
▶ Higher efficiency LEDs
▶ Reduced internal reflections within the LED

APPLICATIONS
▶ LEDs and LDs

PATENT STATUS

<table>
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<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
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<tr>
<td>United States Of America</td>
<td>Issued Patent</td>
<td>9,130,119</td>
<td>09/08/2015</td>
<td>2007-317</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
▶ 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
▶ 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
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
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
Method for Growing High-Quality Group III-Nitride Crystals
Controlled Photoelectrochemical (PEC) Etching by Modification of Local Electrochemical Potential of Semiconductor Structure
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
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
GaN Interlayer Design to Fully Eliminate V-Pits from InGaN Pseudo-Substrates
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
Improved Manufacturing of Solid State Lasers via Patterning 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
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
Photoelectrochemical Etching for Chip Shaping Of LEDs
III-V Nitride Device Structures on Patterned Substrates
Activation of P-Type Layers of Tunnel Junctions in Micro-LEDs
Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration
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
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
▶ 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
▶ Integration And Mass Transfer Of Microleds
▶ 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