**Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance**

**Tech ID: 23656 / UC Case 2008-415-0**

**BRIEF DESCRIPTION**

A novel approach to reducing or possibly eliminating the polarization effects in GaN-based optoelectronic devices.

**BACKGROUND**

Conventional nitride technology for electronic and optoelectronic devices employs nitride films grown along the polar c-direction. However, conventional structures in III-nitride based optoelectronic and electronic devices suffer from the undesirable quantum-confined Stark effect (QCSE), due to the existence of strong piezoelectric and spontaneous polarizations. One approach to eliminating the polarization effects in devices is to grow the devices on nonpolar planes of the crystal. Unfortunately, growth on nonpolar nitrides remains challenging and has not yet been widely adopted in the III-nitride industry.

**DESCRIPTION**

Researchers at the University of California, Santa Barbara have developed a novel approach to reducing or possibly eliminating the polarization effects in GaN-based optoelectronic devices. This approach includes growing the devices on semipolar planes of the crystal. Using semipolar planes instead of c-plane nitrides will reduce total polarization, and there may even be zero polarization for specific alloy compositions. Reducing the polarization field allows for the growth of thicker quantum wells. With thicker quantum wells, higher Indium composition and thus longer wavelength emission can be achieved. The novel approach allows for the fabrication of blue, green, and yellow LEDs on semipolar (Al, In, Ga, B)N semiconductor crystals.

**ADVANTAGES**

- Growth of thicker quantum wells
- Reduced polarization fields in the device structure
- Reduced defect formation in the active layer
- Longer wavelength emission

**APPLICATIONS**

- Green, yellow, and blue GaN based light emitting diodes
- Laser diodes
- Multi-junction solar cells

**PATENT STATUS**

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<td>Issued Patent</td>
<td>8,299,452</td>
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**OTHER INFORMATION**

**KEYWORDS**

indssl, indLED, green LED, blue LED, infeat

**CATEGORIZED AS**

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

**RELATED CASES**

- 2008-415-0
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
- 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
- Eliminating Misfit Dislocations with In-Situ Compliant Substrate Formation
- 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
- 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 (Al,In,Ga,B)N Films via MOCVD