Low-Droop LED Structure on GaN Semi-polar Substrates
Tech ID: 24988 / UC Case 2011-832-0

BRIEF DESCRIPTION
An LED structure of GaN thin films grown by metal organic chemical vapor deposition (MOCVD) on (20-2-1) semi-polar GaN substrates that demonstrate low efficiency droop.

BACKGROUND
When III-nitride-based LEDs are grown on nonpolar and semi-polar planes, unbalanced in-plane biaxial strain causes the curvature of the highest valence band to increase. The result is an increase in symmetry between the valence band and conduction band curvatures. For wide bandgap materials, symmetric conduction and valence bands may suppress Auger recombination, which is the mechanism widely accepted as being responsible for efficiency droop. Particularly in high indium composition layers, it has been observed that quantum wells grown on certain semi-polar planes may have superior alloy uniformity to devices grown on c-plane; this difference should lead to reduced alloy scattering and the devices should demonstrate reduced efficiency droop in general.

DESCRIPTION
Researchers at UC Santa Barbara have developed an LED structure of GaN thin films grown by metal organic chemical vapor deposition (MOCVD) on (20-2-1) semi-polar GaN substrates that demonstrate low efficiency droop. These devices provide a pathway to nitride-based devices that are free from the droop effect. The structure incorporates n-type superlattice layers located below the quantum wells (QW), a QW active region of at least three periods, and p-type superlattice layers above the QWs. Devices grown on the (20-2-1) plane have shown that they have superior alloy uniformity, reduced alloy scattering, and thus diminished efficiency droop.

ADVANTAGES
· Superior alloy uniformity
· Greatly reduced alloy scattering
· Reduced efficiency droop

APPLICATIONS
· Solid state lighting systems

PATENT STATUS

<table>
<thead>
<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
<th>Dated</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States Of America</td>
<td>Issued Patent</td>
<td>8,686,397</td>
<td>04/01/2014</td>
<td>2011-832</td>
</tr>
</tbody>
</table>

CATEGORIZED AS
· Energy
· Lighting

RELATED CASES
2011-832-0

INVENTORS
· DenBaars, Steven P.
· Feezell, Daniel F.
· Nakamura, Shuji
· Pan, Chih Chien
· Tanaka, Shinichi
· Zhao, Yuji

OTHER INFORMATION
KEYWORDS
indssl, indled, MOCVD, indfeat

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
· 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
- 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 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