Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of Optically Pumped and Electrically Injected III-Nitride LEDs

Tech ID: 23890 / UC Case 2014-416-0

BRIEF DESCRIPTION
A novel device structure for III-nitride devices grown on non-polar or semipolar planes.

BACKGROUND
The usefulness of III-nitrides has been well established for fabrication of visible and ultraviolet optoelectronic devices and high power electronic devices. Growing these devices on nonpolar or semipolar planes of the crystal is a popular solution for reducing the polarization effects. One of the challenges of nonpolar and semipolar growth is that when green III-nitride LEDs and LDs are grown with active regions with high indium contents, the active region can form extended defects and can easily be degraded by subsequent high temperature growth steps. This degradation is due to the growth of the p-type layers after the growth of the active region, which uses high temperatures and impedes device performance.

DESCRIPTION
A novel device structure has been developed for III-nitride devices grown on non-polar or semipolar planes that does not involve the growth of p-type layers after the active region. This configuration reduces the defects and device degradation common in III-nitride LEDs and LDs grown on semipolar planes, and has the potential for creating green III-nitride LEDs and LDs with improved performance and higher wall-plug efficiency.

ADVANTAGES
· Reduced contact resistance, absorption loss, and spreading resistance in p-GaN devices
· Decreased operating voltage of LEDs and LDs leads to increased wall-plug efficiency
· Reduced thermal losses from resistive p-GaN layers

APPLICATIONS
· Light emitting diodes (LEDs)
· Laser diodes (LDs)

PATENT STATUS

<table>
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<tr>
<th>Country</th>
<th>Type</th>
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<tr>
<td>United States Of America</td>
<td>Issued Patent</td>
<td>10,186,835</td>
<td>01/22/2019</td>
<td>2014-416</td>
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ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
· Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
· Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
· Improved Manufacturing of Semiconductor Lasers
· Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
· Enhancing Growth of Semipolar (Al,Ga,N) Films via MOCVD
· GaN-Based Thermoelectric Device for Micro-Power Generation
· Growth of High-Quality, Thick, Non-Polar M-Plane GaN Films
· Method for Growing High-Quality Group III-Nitride Crystals
· Growth of Planar Semi-Polar Gallium Nitride
· Photonic Structures for Efficient Light Extraction and Conversion in Multi-Color LEDs
· MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
· Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
· Low Temperature Deposition of Magnesium Doped Nitride Films
Growth of Polyhedron-Shaped Gallium Nitride Bulk Crystals
Improved Manufacturing of Solid State Lasers via Patternning of Photonic Crystals
Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure
Phosphor-Free White Light Source
Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate
High Efficiency LED with Optimized Photonic Crystal Extractor
Packaging Technique for the Fabrication of Polarized Light Emitting Diodes
LED Device Structures with Minimized Light Re-Absorption
III-V Nitride Device Structures on Patterned Substrates
Growth of Semipolar III-V Nitride Films with Lower Defect Density
Improved GaN Substrates Prepared with Ammonothermal Growth
Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance
Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration
Photoelectrochemical Etching Of P-Type Semiconductor Heterostructures
Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping
High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)
Nonpolar III-Nitride LEDs With Long Wavelength Emission
Method for Increasing GaN Substrate Area in Nitride Devices
Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Lift-off Technique
Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
Low-Drop LED Structure on GaN Semi-polar Substrates
Improved Fabrication of Nonpolar InGaN Thin Films, Heterostructures, and Devices
Growth of High-Performance M-plane GaN Optical Devices
Method for Enhancing Growth of Semipolar Nitride Devices
Transparent Mirrorless (TML) LEDs
Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
Planar, Nonpolar M-Plane III-Nitride Films Grown on Miscut Substrates
High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
High Light Extraction Efficiency III-Nitride LED
Tunable White Light Based on Polarization-Sensitive LEDs
Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
Improved Anisotropic Strain Control in Semipolar Nitride Devices
III-Nitride Tunnel Junction with Modified Interface
Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
Contact Architectures for Tunnel Junction Devices
Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
Methods for Fabricating III-Nitride Tunnel Junction Devices
Multifaceted III-Nitride Surface-Emitting Laser
Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
Efficient Implementation of a Tunnel Junction Contact on a Nitride-Based Edge-Emitting Laser Diode
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
Distributed Feedback Laser with Transparent Conducting Oxide Grating