III-Nitride-Based Devices Grown With Relaxed Active Region
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BACKGROUND

Fierce market competition in high-resolution displays and augmented/virtual reality (AR/VR) technologies is increasing the demand for highly efficient micro-LEDs, driving researchers to investigate indium gallium nitride (InGaN)-based LEDs due to their high blue and green external quantum efficiency (EQE). A substantial obstacle in fabricating high efficiency InGaN LEDs is growing a high-indium-containing InGaN layer while maintaining favorable structural and crystal qualities, due to the coherent strain of InGaN layers on the GaN substrate. Through indium desorption, crystal degradation, and rough surface morphology, strain between the device layers comes at a cost of overall device efficiency; especially for long-wavelength LEDs. Improving indium incorporation and crystal quality, decreasing defects, and growing devices at higher temperatures are key to enabling mass manufacture of long-wavelength III-nitride based devices.

DESCRIPTION

Researchers at the University of California, Santa Barbara have fabricated III-nitride-based devices with a relaxed active region that improve on the crystal quality, defect density, and surface morphology of previous demonstrations. This technology uses a thin thermally decomposed InGaN underlayer and a thin GaN or InGaN decomposition stop layer as the strain compliant layer. These novel components improve the crystal quality, reduce defects, improve surface morphologies, and ultimately enhance the final electrical and optical properties of the device. In addition, growing a relaxed active region will minimize the compositional pulling effect, which will allow for higher temperature quantum well growth and higher efficiency for long wavelength emitting devices.

ADVANTAGES

- Enhances key device performance with improvements to crystal quality, defect density, surface morphology and growth temperature
- Increases efficiency in long-wavelength devices

APPLICATIONS

- LEDs, micro-LEDs and Laser Diodes
- Augmented/virtual reality
- High-resolution displays

PATENT STATUS

Patent Pending

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
- 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
• 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 Pattern 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