Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices  
Tech ID: 25247 / UC Case 2005-668-0

BRIEF DESCRIPTION
A method to grow semipolar (Ga, Al, In, B)N thin films, heterostructures, and devices on suitable substrates or planar templates in which a large area of the semipolar film is parallel to the substrate surface.

BACKGROUND
The usefulness of gallium nitride (GaN) and its ternary and quaternary compounds incorporating aluminum and indium has been well established for fabrication of visible and ultraviolet optoelectronic devices. Current nitride technology for these devices uses nitride films grown along the polar c-direction; however, quantum-well active regions in devices suffer from the quantum-confined Stark effect (QCSE). One way to combat the issue is to grow films on semipolar planes of GaN in order to improve device performance by reduce polarization effects and increasing the efficiency of optical transitions.

DESCRIPTION
Researchers at UC Santa Barbara have developed a method to grow semipolar (Ga, Al, In, B)N thin films, heterostructures, and devices on suitable substrates or planar templates in which a large area of the semipolar film is parallel to the substrate surface.

The method uses vapor phase epitaxy, such as metalorganic chemical vapor deposition (MOCVD), in order to grow the semipolar structures. Additionally, this technique alters the crystal growth orientation in order to reduce polarization effects in nitride thin films. This method is stable, energy efficient and cost-effective.

ADVANTAGES
▶ Reduces the negative impact of polarization
▶ Improved device efficiency
▶ Improved crystal growth orientation

APPLICATIONS
▶ LEDs and Laser Diodes (LDs)
▶ Semiconductors

PATENT STATUS

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<th>Type</th>
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<td>United States Of America</td>
<td>Issued Patent</td>
<td>9,793,435</td>
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<td>9,231,376</td>
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<td>20180013035</td>
<td>01/11/2018</td>
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RELATED CASES
2005-668-0

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
▶ Nonpolar (Al, B, In, Ga)N Quantum Well Design
▶ Improved Manufacturing of Semiconductor Lasers
▶ Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
- Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
- Enhancing Growth of Semipolar (Al,In,Ga,B)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
- Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
- 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 Polynedron-Shaped Gallium Nitride Bulk Crystals
- Improved Manufacturing of Solid State Lasers via Patterned of Photonic Crystals
- Novel Current-Blocking Layer in High-Power Current Aperture Vertical Electron Transistors (CAVETs)
- 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
- (In,Ga,)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- Polarization-Doped Field Effect Transistors with Increased Performance
- Oxyfluoride Phosphors for Use in White Light LEDs
- 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
- High-Quality N-Face GaN, InN, AlN by MOCVD
- 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
- Photoelectrochemical Etching for Chip Shaping Of LEDs
- Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
- Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of Optically Pumped and Electrically Injected III-Nitride LEDs
- Defect Reduction in GaN films using in-situ SiNx Nanomask
- Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
- Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patternning
- 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 Growing Self-Assembled Quantum Dot Lattices
- Method for Increasing GaN Substrate Area in Nitride Devices
- GaN-based Vertical Metal Oxide Semiconductor and Junction Field Effect Transistors
- Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Liftoff Technique
- Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- Low-Droop 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
- Solid Solution Phosphors for Use in Solid State White Lighting Applications
- 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
Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
Increased Light Extraction with Multistep Deposition of ZnO on GaN
Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
Contact Architectures for Tunnel Junction Devices
A Structure For Increasing Mobility In A High-Electron-Mobility Transistor
Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
III-N Based Material Structures and Circuit Modules Based on Strain Management
Methods for Fabricating III-Nitride Tunnel Junction Devices
Achieving "Active P-Type Layer/Layers" In III-Nitride Epitaxial Or Device Structures Having Buried P-Type Layers
Multifaceted III-Nitride Surface-Emitting Laser
Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs
Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
Gated Electrodes For Electrolysis And Electrosynthesis
Methods for Locally Changing the Electric Field Distribution in Electron Devices
Continuous Fluidic Printing Of MicroLEDs
Creating and Releasing Nanoscale Light Emitting Devices from Their Growth Substrates
Colloidal Lithography-Enabled Creation of Metasurface-Integrated MicroLEDs and Devices
Efficient Implementation of a Tunnel Junction Contact on a Nitride-Based Edge-Emitting Laser Diode
Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
Fabrication of Relaxed Semiconductor Films without Crystal Defects
Enhancement of Semi-Polar Gallium Nitride Surface Morphology in Photo-Electrochemical Undercut Etching
Transparent Vertical Cavity Surface Emitting Laser for Augmented and Mixed Reality Displays
Control Of Photoelectrochemical Etch Parameters For Minimization of Interfacial Roughness of Light Emitting Device Structures
High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
Distributed Feedback Laser with Transparent Conducting Oxide Grating
III-N Transistor With Stepped Cap Layers