Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy

Tech ID: 10267 / UC Case 2003-224-0

**BRIEF DESCRIPTION**


**BACKGROUND**

Gallium nitride (GaN) and its ternary and quaternary compounds incorporating aluminum and indium (AlGaN, InGaN, AlInGaN) have proven useful in fabricating visible and ultraviolet optoelectronic devices and high-power electronic devices. GaN and its alloys are most stable in the hexagonal wurtzite crystal structure. However, the positions of the gallium and nitrogen atoms in this structure leads to polarization of the GaN crystals along the c-axis. Virtually all GaN-based devices are grown parallel to the polar c-axis, due to the relative ease of growing planar Ga-face planes. In addition, strain at the interfaces between adjacent dissimilar layers causes piezoelectric polarization and subsequent charge separation. These polarization effects decrease the likelihood of electron and hole interaction, which is essential for the operation of light-emitting devices. As a result, eliminating these polarization effects inherent to c-axis oriented devices could greatly enhance the efficiency of GaN light-emitting devices. In addition, defect densities in directly grown GaN films are much higher than those found in more traditional III/V semiconductor systems, such as the arsenides and phosphides.

**DESCRIPTION**

Scientists at the University of California have developed a novel method for producing low-dislocation density non-polar GaN by hydride vapor phase epitaxy (HVPE). This invention complements the method for producing thick planar films of a-plane GaN by HVPE (UC Case 2003-225) by allowing single-step fabrication of reduced defect density material.

**ADVANTAGES**

- Significantly improves film quality by allowing fabrication of enhanced GaN substrate layers for subsequent non-polar device fabrication;
- Greatly improves subsequent device performance.

**APPLICATIONS**

- Fabrication of low-dislocation density GaN by HVPE.

This technology is available for a non-exclusive license. See below for a selection of the patents and patent applications related to this invention. Please inquire for full patent portfolio status.

**PATENT STATUS**

<table>
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<tr>
<th>Country</th>
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<td>United States Of America</td>
<td>Issued Patent</td>
<td>7,220,658</td>
<td>05/22/2007</td>
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**RELATED TECHNOLOGIES**
Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
- Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
- High Efficiency LED with Optimized Photonic Crystal Extractor
- Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
- Edge-Emitting Laser Diode with Via-Activated Tunnel Junction Contact
- Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
- Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
- Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Liftoff Technique
- Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- Gallium-containing MicroLEDs for Displays
- High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
- Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
- Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
- 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 Semiconductor Laser Diodes
- Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
- Phosphor-Free White Light Source
- Volumetric Hole Injection with Intentional V-Defects
- Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure
- Low Temperature Deposition of Magnesium Doped Nitride Films
- Transparent Mirrorless (TML) LEDs
- Improved GaN Substrates Prepared with Ammonothermal Growth
- Laser Diode With Tunnel Junction Contact Surface Grating
- Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
- High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
- Method for Growing Self-Assembled Quantum Dot Lattices
- 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
- Near-Infrared, Flip-Chip, TCO-Clad, InGaN Quantum Dot Laser Diode
- Incorporating Temperature-Sensitive Layers in III-N LED Devices
- 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
- MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
- Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
- (Al, In,Ga, B)N Device Structures
- Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs
- Methods for Fabricating III-Nitride Tunnel Junction Devices
- 3D Hole Injectors for InAlGaN Light-Emitting Diodes
- Formation of Transparent Integrated MicroLED Displays
- 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
Growth of Semipolar III-V Nitride Films with Lower Defect Density

III-Nitride Tunnel Junction LED with High Wall Plug Efficiency

In-Situ Methods Of Preventing Interfacial Impurities And Dry Etch-Induced Damage In Regrown III-Nitride Structures

Enhanced Hole Injection by P-Type Active Region and Lateral Injection in InAlGaN LEDs

Improved Manufacturing of Solid State Lasers via Patternning of Photonic Crystals

Solid Solution Phosphors for Use in Solid State White Lighting Applications

Multifaceted III-Nitride Surface-Emitting Laser

Tunable White Light Based on Polarization-Sensitive LEDs

Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN

III-Nitride VCSEL with a High Indium Content Active Region

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

Photoelectrochemical Etching for Chip Shaping Of LEDs

III-V Nitride Device Structures on Patterned Substrates

Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration

Method for Increasing GaN Substrate Area in Nitride Devices

Burying Impurities And Defects In Regrown III-Nitride Structures

Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy

Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate

GaN-Based Thermoelectric Device for Micro-Power Generation

Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning

Improved Manufacturing of Semiconductor Lasers

LED Device Structures with Minimized Light Re-Absorption

Improved Light Extraction with Geometrically Tuned LED Arrays

Growth of Planar Semi-Polar Gallium Nitride

Nonpolar (Al, 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

Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)

Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping

Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures

Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD