Method for Increasing GaN Substrate Area in Nitride Devices
Tech ID: 24795 / UC Case 2007-675-0

BRIEF DESCRIPTION
A technique for producing large-area, high-quality freestanding non-polar and semi-polar nitride substrates via multiple slicing and growth steps.

BACKGROUND
Gallium nitride (GaN) and its compounds that incorporate aluminum and indium have been well established for fabrication of optoelectronic devices and high-power electronic devices. Typically, these devices are grown epitaxially using growth techniques such as molecular beam epitaxy, metalorganic chemical vapor deposition, and hydride vapor phase epitaxy. These methods in current nitride technology employ nitride films that are grown along the polar c-direction, where multiple basal plane axes of GaN and its alloys are aligned perpendicular to the c-axis. However, these devices suffer from the quantum-confined Stark effect (QCSE), which causes spontaneous polarizations.

One possibility for eliminating spontaneous polarization in GaN optoelectronic devices is to grow them on non-polar planes of the crystal. Subsequent non-polar layers are equivalent to the top plane, assuring the bulk crystal will not be polarized along the growth direction.

DESCRIPTION
Researchers at the University of California, Santa Barbara have developed a technique for producing large-area, high-quality freestanding non-polar and semi-polar nitride substrates via multiple slicing and growth steps. The available surface area is increased geometrically by changing the growth direction of thick-film growth steps. Multiple growth steps with different growth directions that are not orthogonal to the prior substrate surface are utilized, which enlarges the surface area of the final crystal plane. The number of process repeats (growth/slice/polish) and the angles of the slice steps depend on the final crystal plane. This invention is pertinent to all nitrides, and results in reduced defect densities.

ADVANTAGES
• Total polarization is eliminated (non-polar) or reduced greatly (semi-polar)
• Improved device performance
• Applicable to all nitride-based optoelectronic devices

APPLICATIONS
• Optoelectronic devices (LEDs, LDs)
• High-power electronic devices (transistors)

PATENT STATUS

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<td>Issued Patent</td>
<td>8,729,671</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
• 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)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 Polyhedron-Shaped Gallium Nitride Bulk Crystals
Improved Manufacturing of Solid State Lasers via Patterned 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
(In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved 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
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 A/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
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-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
Solid Solution Phosphors for Use in Solid State White Lighting Applications
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
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
Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
Methods for Fabricating III-Nitride Tunnel Junction Devices
Multiacetate 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
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
Unidirectional Photoluminescence from GaN/(In)GaN Quantum Well Metasurfaces
Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures
Contact to III-Nitride Tunnel Junction Devices Using Narrow Current Spreading Layer and Current Blocking Layer
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
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