Growth of Planar Semi-Polar Gallium Nitride
Tech ID: 21912 / UC Case 2005-471-0

BRIEF DESCRIPTION
A technique for the growth of planar films of semi-polar nitrides, in which a large area of (Al, In, Ga)N is grown parallel to the substrate surface.

BACKGROUND
Current nitride technology for electronic and optoelectronic devices employs nitride films grown along the polar c-direction. However, conventional c-plane quantum well structures in III-nitride based optoelectronic and electronic devices suffer from the undesirable quantum-confined Stark effect (QCSE), due to the existence of strong piezoelectric effects and spontaneous polarizations. The strong built-in electric fields along the c-direction cause spatial separation of electrons and holes that in turn give rise to restricted carrier recombination efficiency, reduced oscillator strength, and red-shifted emission. The growth of non-polar GaN remains challenging and has not yet been widely adopted in the III-nitride industry.

DESCRIPTION
Researchers at the University of California, Santa Barbara have developed a technique for the growth of planar films of semi-polar nitrides, in which a large area of (Al, In, Ga)N is grown parallel to the substrate surface. For example, samples can be grown on 10 mm x 10 mm or 2 inch diameter substrates. The advantage of semi-polar over c-plane nitride films is the reduction in polarization and the associated increase in internal quantum efficiency for certain devices.

ADVANTAGES
▶ Reduction in polarization and the associated increase in internal quantum efficiency for certain devices
▶ Easier to grow compared to non-polar nitride films

APPLICATIONS
▶ Production of planar semi-polar gallium nitride

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>
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<td>7,220,324</td>
<td>05/22/2007</td>
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RELATED CASES
2005-471-0

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

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▶ Nakamura, Shuji
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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,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
- 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 Patterning 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,AI)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 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 Growing Self-Assembled Quantum Dot Lattices
- 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-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
- 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
- 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
- Wafer Bonding for Embedding Active Regions with Relaxed Nanofeatures
- High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
- Distributed Feedback Laser with Transparent Conducting Oxide Grating
- Eliminating Plasma Damage for Beta-Phase Gallium Oxide Transistors
- Retaining Injection Efficiency and Optical Properties of Laser Diodes with Built-in Polarization Fields