MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
Tech ID: 21917 / UC Case 2005-566-0

BRIEF DESCRIPTION
Methods for successfully growing planar non-polar m-plane gallium nitride (GaN) with metalorganic chemical vapor deposition (MOCVD).

BACKGROUND
It is relatively easy to grow c-plane GaN due to its large growth window (pressure, temperature and precursor flows) and its stability. However, as a result of c-plane growth, each material layer suffers from separation of electrons and holes to opposite faces of the layers. Furthermore, strain at the interfaces between adjacent layers gives rise to piezoelectric polarization, causing further charge separation. Such polarization effects decrease the likelihood of electrons and holes recombining, causing the device to perform poorly.

DESCRIPTION
Researchers at the University of California, Santa Barbara have developed methods for successfully growing planar non-polar m-plane gallium nitride (GaN) with metalorganic chemical vapor deposition (MOCVD). These methods take advantage of non-polar nature of m-plane GaN to eliminate polarization fields, and gives rise to flexibility in growth variables, such as temperature, pressure and precursor flows, utilizing the advantage of m-GaN stability during growth.

ADVANTAGES
- Eliminates polarization fields
- More flexibility in growth variables

APPLICATIONS
Growth of non-polar GaN films
GaN-based devices

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

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<td>United States Of America</td>
<td>Issued Patent</td>
<td>8,795,440</td>
<td>08/05/2014</td>
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<td>8,097,481</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)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
- 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,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 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) 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
- 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
- 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 Nanostructures
- 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