Improved Fabrication of Nonpolar InGaN Thin Films, Heterostructures, and Devices
Tech ID: 25014 / UC Case 2004-495-0

BRIEF DESCRIPTION
A method for fabricating high-quality indium-containing epitaxial layers, heterostructures, and devices based on InGaN growth on GaN substrates.

BACKGROUND
GaN and its alloys (AlGaN, InGaN, AlInGaN) have been established as effective for fabrication of visible and ultraviolet optoelectronic devices and high-power electronic devices. These devices are most often grown along the polar c-direction, using a variety of growth techniques, including molecular beam epitaxy (MBE), metalorganic chemical vapor deposition (MOCVD), or hydride vapor phase epitaxy (HVPE). Growing devices in the polar c-direction results in charge separation, spontaneous polarization, and degraded device performance. Growth of such devices along a nonpolar axis could significantly improve their performance, but InGaN-based devices have previously encountered problems with growth conditions and material quality.

DESCRIPTION
UC Santa Barbara researchers have developed a method for fabricating high-quality indium-containing epitaxial layers, heterostructures, and devices based on InGaN growth on GaN substrates. These InGaN films are grown along the nonpolar direction using a metalorganic chemical vapor deposition technique, and result in the successful creation of violet and near-ultraviolet LEDs and LDs. Previous issues related to the growth of InGaN-based devices, such as gross surface roughening, low indium incorporation, and indium desorption in InGaN heterostructures have been overcome with this technique.

ADVANTAGES
- Variability in layer thickness
- Violet and near-ultraviolet light emission
- Growth of nonpolar InGaN at a reduced temperature
- Growth of InGaN layers at or near atmospheric pressure

APPLICATIONS
- LEDs
- Laser diodes (LDs)

PATENT STATUS

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<td>United States Of America</td>
<td>Issued Patent</td>
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<td>7,186,302</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
- 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 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,Al)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: Monolithically Integrated or 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-Claudding-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) Lift-off Technique

Optimization of Laser Bar Orientation for Nonpolar Laser Diodes

UV Optoelectronic Devices Based on Nonpolar and Semipolar AlInN and AlInGaN Alloys

Low-Drop LED Structure on GaN Semi-polar Substrates

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

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 Electrolysisthesis

Methods for Locally Changing the Electric Field Distribution in Electronic 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

Unidirectional Photoluminescence with GaN/InGaN 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

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 Photoselectrochemical 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