Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
Tech ID: 10268 / UC Case 2003-225-0

BRIEF DESCRIPTION
A novel method for growing high-quality thick films of a-plane GaN suitable for use as substrates in homoepitaxial device layer regrowth.

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.

DESCRIPTION
Scientists at the University of California have developed a novel method for growing high-quality thick films of a-plane GaN suitable for use as substrates in homoepitaxial device layer regrowth. This invention can be used in conjunction with a method for growing reduced-dislocation density non-polar GaN by hydride vapor phase epitaxy (HVPE) (UC Case 2003-224).

ADVANTAGES
▶ Allows for the production of thick a-plane GaN films for use as substrates for polarization-free device growth;
▶ Produces films of superior quality that are suitable for subsequent device regrowth by a variety of growth techniques.

APPLICATIONS
▶ Fabrication of 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>
<thead>
<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
<th>Dated</th>
<th>Case</th>
</tr>
</thead>
</table>

CONTACT
University of California, Santa Barbara Office of Technology & Industry Alliances
dobis@tia.ucsb.edu
tel: View Phone Number.

INVENTORS
▶ Craven, Michael D.
▶ DenBaars, Steven P.
▶ Fini, Paul T.
▶ Haskell, Benjamin A.
▶ Matsuda, Shigemasa
▶ Nakamura, Shuji
▶ Speck, James S.

OTHER INFORMATION
KEYWORDS
indssl, indbulk, HVPE, GaN, gallium nitride, ceniIEE

CATEGORIZED AS
▶ Engineering
▶ Semiconductors
▶ Design and Fabrication

RELATED CASES
2003-225-0
RELATED TECHNOLOGIES
▶ Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
▶ Reduced Dislocation Density of Non-Polar GaN Grown 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 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,Aj)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 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
Wafer Bonding for Embedding Active Regions with Relaxed Nanostructures
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
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