Optimization of Laser Bar Orientation for Nonpolar Laser Diodes

Tech ID: 24986 / UC Case 2007-425-0

BRIEF DESCRIPTION
A method for the growth and fabrication of nonpolar laser diodes.

BACKGROUND
Growing nitride laser diodes along the polar c-direction causes a polarization-induced electric field that causes a large effective hold mass that is detrimental to performance. Alternatively, growing nitride thin films along a nonpolar axis offers a means of eliminating polarization effects and reducing the effective hole mass in device structures. These changes should help to decrease the current densities necessary to generate optical gain in nitride laser diodes. In particular, nonpolar nitride laser bars should be properly oriented with regards to the planes of semiconductor crystals in order to achieve the aforementioned benefits.

DESCRIPTION
Researchers at UC Santa Barbara have developed a method for the growth and fabrication of nonpolar laser diodes. The structures can be grown either directly on free-standing nonpolar substrates or on nonpolar template layers pre-deposited on a foreign substrate. Many growth techniques are suitable for the method, including metalorganic chemical vapor deposition (MOCVD), hydride vapor phase epitaxy (HVPE), and molecular beam epitaxy (MBE). For m-plane nitride laser diodes, optical gain is maximized when laser bars are oriented along the c-axis and minimized for laser bars oriented along the a-axis; for a-plane devices, optical gain is maximized for laser bars oriented along the c-axis and minimized when oriented along the m-axis. This in-plane, orientation-dependent gain is a phenomenon that is currently unique to nonpolar nitride laser diodes.

ADVANTAGES
- Superior manufacturability of nitride laser diodes
- Improved device performance through elimination of polarization-induced electric fields and reduction of effective hole mass
- Decreased current densities necessary to generate optical gain
- Less heat generation, longer device lifetimes, and higher production yields

APPLICATIONS
- Solid-state lighting systems, including projection displays
- High-resolution printers
- High-density optical data storage systems
- Optical sensing

PATENT STATUS

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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 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
Semipolar 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) Lift-off Technique
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
Multilayered 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 Relaeking Nanoscale Light Emitting Devices from Their Growth Subraetes
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
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