Growth of High-Performance M-plane GaN Optical Devices

Tech ID: 25015 / UC Case 2007-316-0

BRIEF DESCRIPTION

A method using MOCVD growth conditions to achieve high performance m-plane GaN optical devices, including LEDs and LDs.

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). However, growing devices along the polar c-direction results in charge separation, spontaneous polarization, and degraded device performance. One possible alternative is to grow devices along the m-plane, a nonpolar GaN plane where there is no net polarization, radiative efficiencies should be higher, and no wavelength shift occurs. However, nonpolar GaN devices typically have output powers and efficiencies that are well below c-plane LEDs, mainly due to high dislocation densities.

DESCRIPTION

Researchers at UC Santa Barbara have invented a method using MOCVD growth conditions to achieve high performance m-plane GaN optical devices, including LEDs and LDs. Key components of the invention include using a low defect density substrate or template, thick quantum wells, a low temperature p-GaN growth technique, and a transparent conducting oxide for the p-contact. It is important that defects and stacking faults are eliminated from the active region, because this decreases the number of non-radiative recombination centers and improves carrier transport properties. The p-type GaN is grown at a much lower temperature than the active region temperature, and transparent conducting oxides are used to enhance light extraction. The method can be extended to the use of a three-color active region, which can produce red, green and blue (RGB) emissions. This results in the emission of white light that is polarized due to the nature of m-plane optical devices.

ADVANTAGES

· Emission of polarized, white light

· Very high output powers and high efficiencies

· Enhanced light extraction due to use of transparent oxide electrode (ITO)

CONTACT

Pasquale S. Ferrari
ferrari@tia.ucsb.edu
tel: .

INVENTORS

- DenBaars, Steven P.
- Kim, Kwang Choong
- Nakamura, Shuji
- Sato, Hitoshi
- Schmidt, Mathew C.
- Speck, James S.

OTHER INFORMATION

KEYWORDS

indssl, indled, MOCVD, GaN, semipolar

CATEGORIZED AS

- **Engineering**
- **Energy**
  - Lighting
  - Other
- **Optics and Photonics**
  - All Optics and Photonics
- **Semiconductors**
  - Design and Fabrication

RELATED CASES

2007-316-0

- Method can be applied to the a-plane or any of the semipolar planes of GaN

APPLICATIONS

- LEDs
- Laser diodes (LDs)
- Vertical cavity surface emitting lasers (VCSELs)

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	8,956,896	02/17/2015	2007-316
United States Of America	Issued Patent	8,178,373	05/15/2012	2007-316
United States Of America	Issued Patent	7,842,527	11/30/2010	2007-316

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
- ▶ Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
- ▶ Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- ▶ Eliminating Misfit Dislocations with In-Situ Compliant Substrate Formation
- ▶ III-Nitride-Based Vertical Cavity Surface Emitting Laser (VCSEL) with a Dielectric P-Side Lens
- ▶ Aluminum-cladding-free Nonpolar III-Nitride LEDs and LDs
- ▶ Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
- ▶ Defect Reduction in GaN films using in-situ SiNx Nanomask
- ▶ Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
- ▶ Low Temperature Deposition of Magnesium Doped Nitride Films
- ▶ Transparent Mirrorless (TML) LEDs
- ▶ Improved GaN Substrates Prepared with Ammonothermal Growth
- ▶ Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
- ▶ Method for Enhancing Growth of Semipolar Nitride Devices
- ▶ Ultraviolet Laser Diode on Nano-Porous AlGaN template
- ▶ Improved Reliability & Enhanced Performance of III-Nitride Tunnel Junction Optoelectronic Devices
- ▶ Growth of Polyhedron-Shaped Gallium Nitride Bulk Crystals
- ▶ Nonpolar III-Nitride LEDs With Long Wavelength Emission
- ▶ Improved Fabrication of Nonpolar InGaN Thin Films, Heterostructures, and Devices
- ▶ Growth of High-Quality, Thick, Non-Polar M-Plane GaN Films
- ▶ Method for Growing High-Quality Group III-Nitride Crystals
- ▶ Controlled Photoelectrochemical (PEC) Etching by Modification of Local Electrochemical Potential of Semiconductor Structure
- ▶ Oxyfluoride Phosphors for Use in White Light LEDs
- ▶ Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- ▶ (In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- ▶ Thermally Stable, Laser-Driven White Lighting Device
- ▶ MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
- ▶ Methods for Fabricating III-Nitride Tunnel Junction Devices

- Low-Droop LED Structure on GaN Semi-polar Substrates
- Contact Architectures for Tunnel Junction Devices
- Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
- Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance
- III-Nitride-Based Devices Grown On Thin Template On Thermally Decomposed Material
- Growth of Semipolar III-V Nitride Films with Lower Defect Density
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- Tunable White Light Based on Polarization-Sensitive LEDs
- Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
- Packaging Technique for the Fabrication of Polarized Light Emitting Diodes
- Improved Anisotropic Strain Control in Semipolar Nitride Devices
- Novel Multilayer Structure for High-Efficiency UV and Far-UV Light-Emitting Devices
- III-V Nitride Device Structures on Patterned Substrates
- Method for Increasing GaN Substrate Area in Nitride Devices
- High-Intensity Solid State White Laser Diode
- Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact
- GaN-Based Thermoelectric Device for Micro-Power Generation
- Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
- LED Device Structures with Minimized Light Re-Absorption
- Growth of Planar Semi-Polar Gallium Nitride
- High-Efficiency and High-Power III-Nitride Devices Grown on or Above a Strain Relaxed Template
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
- III-Nitride Based VCSEL with Curved Mirror on P-Side of the Aperture
- Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD

University of California, Santa Barbara
Office of Technology & Industry Alliances
342 Lagoon Road, ,Santa Barbara,CA 93106-2055 |
www.tia.ucsb.edu
Tel: 805-893-2073 | Fax: 805.893.5236 | padilla@tia.ucsb.edu