High-Efficiency and High-Power III-Nitride Devices Grown on or Above a Strain Relaxed Template

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BACKGROUND

Long wavelength InGaN emitters are challenging to fabricate and typically less efficient due to the >10% lattice mismatch between indium nitride (InN) and gallium nitride (GaN). The large lattice mismatch causes high strain in the active region which results in defects, degradation of surface morphology and a reduction of indium incorporation (compositional pulling). Growing the InGaN active region on a strain-relaxed InGaN buffer layer will, however, reduce the lattice mismatch between the two layers. This reduces the compositional pulling effect and allows for higher indium incorporation by hotter growth using MOCVD, the dominant method of commercial epitaxial InGaN growth. Hotter growth temperatures tend to lead to higher crystal quality as well, and together these advancements have realized efficient red InGaN LEDs. Until now, this method was not available to InGaN emitters in the green wavelengths.

DESCRIPTION

Researchers at the University of California, Santa Barbara have achieved high efficiency and high power emission in green emitters while growing the devices on or above a strain-relaxed template (SRT). The SRT uses a thin thermally decomposed InGaN underlayer (DL) below an n-type GaN or low indium composition InGaN decomposition stop layer (DSL), on top of which is grown a buffer layer comprising an n-type InGaN/GaN superlattice (SL). For an LD structure, an n-type InGaN waveguiding layer is then grown, followed by an active region, p-type electron blocking layer (EBL), p-type InGaN waveguide and p-type GaN or p-type InGaN layers. For an LED structure, the n-type, p-type or both InGaN waveguiding layers may be omitted. This technology improves the layer structure and growth conditions for green InGaN emitters, resulting in higher power output and higher efficiency.

ADVANTAGES

- Enables high-quality, long-wavelength active regions by mitigating the compositional pulling effect
- Improves the design of the DSL, buffer, waveguide, active region, and p-type cladding layers
- Improves power output and efficiency

APPLICATIONS

- III-Nitride LEDs and Laser diodes
- Emitters in green wavelengths

CONTACT

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

INVENTORS

- Chan, Philip
- Chang, Hsun-Ming
- Nakamura, Shuji
- Rienzi, Vincent

OTHER INFORMATION

KEYWORDS

LED, MOCVD, laser diode, green, strain, InGaN

CATEGORIZED AS

- **Semiconductors**
  - Assembly and Packaging
  - Design and Fabrication
  - Processing and Production

RELATED CASES

2022-775-0

PATENT STATUS

Country	Type	Number	Dated	Case
Patent Cooperation Treaty	Published Application	WO 2023/150550	08/10/2023	2022-775

Additional Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- 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)
- 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
- 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
- High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
- Method for Growing High-Quality Group III-Nitride Crystals
- Controlled Photoelectrochemical (PEC) Etching by Modification of Local Electrochemical Potential of Semiconductor Structure
- Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- 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
- Growth of High-Performance M-plane GaN Optical Devices
- 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
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- 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