Ultraviolet Laser Diode on Nano-Porous AlGaN template

Tech ID: 33108 / UC Case 2023-870-0

BACKGROUND

Efficient AlGaN-based laser diodes (LDs) with emission wavelengths between 300nm and 370nm (UVA LDs) have numerous applications in the fields of lithography, 3D printing, curing, chemical sensing, cytometry, atmospheric LIDAR, and more. Lattice mismatches and dislocations are common obstacles that need to be addressed during the construction of UVA LDs. The devices can be formed on either low dislocation density HVPE-grown GaN substrates or AlN templates grown on sapphire substrates. The former method has yet to demonstrate a device with a suitable lifetime, a result of severe device cracking caused by tensile stress between the substrate and AlGaN layers. The latter method is opposed by the large lattice mismatch between the AlN template and the AlGaN active region when the emission wavelength of the LD is around 350~370nm, creating a large number of dislocations. Relieving either of these methods from their device growth drawbacks would enable a new generation of highly efficient, long-lasting laser devices that outpace their gas phase/solid-state counterparts by a wide margin.

DESCRIPTION

Researchers at the University of California, Santa Barbara have overcome the pain points in constructing efficient ultraviolet laser diodes (UVA LDs) by using a separate confinement structure (SCH or waveguide layer) formed on a nano-porous n-AlGaN layer as the cladding layer. Nano-porous AlGaN has a much lower refractive index than that of a non-porous AlGaN layer with the same Al composition of the AlGaN. This consequently removes the condition to grow thick cladding layers with high Al composition. Instead, similar optical confinement can be achieved with thinner, lower-Al-content layers that can be easily formed on GaN substrates without cracking defects. In addition, the Al composition of the nano-porous n-AlGaN cladding layer is lower than that of conventional structure, which minimizes strain that would otherwise cause cracking defects and also minimizes the generation of new dislocation defects at the interface between the LD structure and nano-porous n-AlGaN cladding. This technology provides a superior structure and technique to fabricate UVA LDs on GaN substrates with dislocation densities of less than $1x10^{6}$ cm^{-2} and a lifetime of over 10,000 hours.

ADVANTAGES

- Prevents cracking and dislocations in UVA LDs formed on GaN substrates
- Enables long device lifetimes of over 10,000 hours
- Improved light confinement compared to alternative structures

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OTHER INFORMATION

KEYWORDS

Ultraviolet laser diode, Nano-porous AlGaN template, Efficient AlGaN-based laser diodes, UVA LDs, Emission wavelengths between 300nm and 370nm, Lattice mismatches, Dislocations HVPE-grown GaN substrates, AlN templates on sapphire substrates, Device cracking, Tensile stress

CATEGORIZED AS

- **Semiconductors**
  - Assembly and Packaging
  - Design and Fabrication
  - Materials

- Processing and Production

RELATED CASES

2023-870-0

APPLICATIONS

- Laser Diodes
- Ultraviolet Laser Diodes (UVA LDs)
- 3D printing
- Curing
- Healthcare
- Chemical sensing
- Atmospheric LiDAR

PATENT STATUS

Country	Type	Number	Dated	Case
Patent Cooperation Treaty	Published Application	WO2024155335	07/25/2024	2023-870

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)
- 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
- 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
- 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
- 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
- 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
- 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

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