Highly Compact, High-Index Dielectric Nanostructures for Deep-Ultraviolet Devices

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BACKGROUND

Efficient generation and management of deep ultraviolet (UV) light (wavelengths from 180 to 300 nm) is important for disinfection, remediation of toxic waste, spectroscopy, electronics manufacturing, and solid-state optoelectronic applications. While significant progress has been made in solid-state AlGaN-based UV light emitter materials, current device configurations utilize absorbing metal reflectors combined with traditional spreading material layers that reduce light-extraction and wall-plug efficiency. As such, new optical elements that reduce absorption losses, maximize UV reflection, and improve thermal management are necessary for accelerating the implementation of solid-state deep UV emitters.

DESCRIPTION

Researchers at University of California, Santa Barbara have created wavelength-tunable, compact optical elements for efficient deep-UV reflection. These novel elements minimize absorption with a low extinction coefficient and >90% reflectance for the entire relevant UV wavelength range (180-365 nm) — all with improved wall-plug efficiency. Unlike reflective UV surfaces and protective dielectric coatings, this optical structure achieves upwards of 85% specular reflection near 200 nm and does not easily oxidize, making the devices commercially competitive compared to their counterpart’s high oxidation rates. Additionally, this invention enables back-end fabrication adaptability to a range of design wavelengths since the reflectors can be formed after epitaxial heterostructure growth and optical testing. This invention leverages intense, wavelength-tunable reflection, and narrow-band wavelength selectivity to become suitable for cleanup filters and narrow-band reflectors for commercially available lasers and LEDs. The compactness, efficiency, fabrication adaptability, and natively-nitride-based and freestanding nature of these elements positions them well to disrupt their current industry alternatives.

ADVANTAGES

▶ Provides intense wavelength-tunable reflection
▶ Achieves high reflectance (>90%) for the entire UV wavelength range
▶ Enables narrow-band wavelength selectivity and free-standing, compact, natively nitride-based device integration

APPLICATIONS

▶ UV LEDs and UV Optoelectronics
▶ Med devices for disinfection and sterilization
▶ Spectroscopy

PATENT STATUS

Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

▶ Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
▶ 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 Devices Grown With Relaxed Active Region
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)

Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide

Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes

Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices

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

Size-Independent Forward Voltage Micro-LED with an Epitaxial Junction

Method for Enhancing Growth of Semipolar Nitride Devices

III-Nitride Tunnel Junction with Modified Interface

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

Increased Light Extraction with Multistep Deposition of ZnO on GaN

Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of Optically Pumped and Electrically Injected III-Nitride LEDs

Selective-Area Mesoporous Semiconductors And Devices For Optoelectronic And Photonic Applications

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

Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy

Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs

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

Photoelectrochemical Etching Of P-Type Semiconductor Heterostructures

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

Improved Manufacturing of Solid State Lasers via Patterning of Photonic Crystals

High Efficiency III-Nitride Devices with Smooth Relaxed InGaN Buffer and Strain Compliant Template

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

High Light Extraction Efficiency III-Nitride LED

III-V Nitride Device Structures on Patterned Substrates

Activation of P-Type Layers of Tunnel Junctions in Micro-LEDs

Method for Increasing GaN Substrate Area in Nitride Devices

Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact

Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy

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

Nonpolar (Al, B, In, Ga)N Quantum Well Design

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