Group III-N Light Emitting Devices Enhanced By Stress From Post-Growth Deposited Films
Tech ID: 33426 / UC Case 2023-99L-0

BACKGROUND

Light-emitting diodes (LED) and laser diodes (LD) made from Group III-N alloys are widely used for solid-state lighting, displays, and data storage, and they are expected to enter new markets for biochemical and environmental sensing, water and workplace sterilization, scene sensing for autonomous vehicles, and optical communication. For all applications, the device output power, brightness, and power conversion efficiency are important parameters, and there is opportunity for improvement in each parameter’s capabilities. Currently, device performance is limited due to the useful radiative transition rate between electrons and holes in the device active region competing with nonradiative processes such as Auger recombination, carrier escape from the active region before recombination, and recombination at defects. Anisotropic strain in devices grown on nonbasal substrates can reduce the average hole mass, thereby increasing the radiative transition rate or optical gain. However, these substrates are generally too expensive for low-cost devices such as LEDs and moderate performance LDs. Theoretically, biaxial in-plane tensile strain and the concomitant compressive out-of-plane strain will also decrease the average hole mass in basal plane devices. However, this tensile in-plane strain is difficult to achieve by epitaxial means because the device active region must use an alloy of larger lattice constant than that of the material surrounding it. Therefore, methods that improve the biaxial in-plane tensile strain and the concomitant compressive out-of-plane strain in Group III-N devices are needed.

DESCRIPTION

Researchers at the University of California, Santa Barbara have created a method to increase the output power, brightness, and power conversion efficiency of LEDs and LDs based on the gallium nitride material system by inducing appropriate strain in the semiconductor. Direct mechanical stress from a combination of films deposited during wafer fabrication is used to induce the required strain, resulting in high-performance low-cost light emitters for use in solid state lighting, macro and micro displays, data storage, printing, sensing, and communication. This method offers significant commercial advantages, as it allows low-cost fabrication of higher performance LEDs and LDs.

ADVANTAGES

▶ Lowers the fabrication cost of high-performance LEDs and LDs
▶ Improves performance of LEDs and LDs based on the gallium nitride material system

APPLICATIONS

▶ Solid-state lighting
▶ Displays
▶ Data storage

PATENT STATUS

Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

▶ 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

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

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

Oxyfluoride Phosphors for Use in White Light LEDs

Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices

(In,Ga,A)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

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

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

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 AlInGaAlloys

Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
Ill-Nitride Based VCSEL with Curved Mirror on P-Side of the Aperture

Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD