Methods for Fabricating III-Nitride Tunnel Junction Devices

Tech ID: 28865 / UC Case 2017-130-0

CONTACT

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

INVENTORS

- DenBaars, Steven P.
- Hwang, David
- Mughal, Asad J.
- Nakamura, Shuji
- Speck, James S.
- Yonkee, Benjamin P.
- Young, Erin C.

OTHER INFORMATION

KEYWORDS

III-nitride devices, tunnel junction, tunel junction devices, indled, edge-emitting laser diodes, laser diodes, MOCVD, indfeat

CATEGORIZED AS

- **Energy**
  - Lighting
- **Engineering**
  - Engineering

RELATED CASES

2017-130-0

BRIEF DESCRIPTION

Methods of physical vapor deposition for III-nitride tunnel junction devices.

BACKGROUND

Current commercially-available III-Nitride light-emitting diodes (LEDs) and edge-emitting laser diodes (EELDs) use an active region in a biased p-n junction to allow for electron and hole injection. However, since p-type gallium nitride (p-GaN) is difficult to contact electrically and has low hole concentration and mobility, p-GaN cannot be used as a current spreading layer and traditional p-contacts will add significant voltage to devices. Despite these inherent problems, all commercial light emitting devices utilize a p-contact and a material other than p-GaN for current spreading, typically transparent conducting oxides (TCO).

A tunnel junction is a diode comprised of a very highly doped (n+/p+) interface that allows for electrons to tunnel between the valence band conduction band. Although in principle a highly doped Esaki-type homojunction diode should provide the lowest-loss tunnel junction, there have been a number of difficulties achieving high quality tunnel junctions in the GaN material system.

DESCRIPTION

Researchers at the University of California, Santa Barbara have satisfied the need for improving the performance of III-nitride devices by overcoming the limitations currently in the field. Improvements include alternative methods for creating tunnel junction devices, including physical vapor deposition (e.g., sputter deposition) and MOCVD regrowth deposition, and III-Nitride tunnel junction improvement through reduction of the magnesium memory effect. Self-emissive III-V micro LED-based displays using low resistance tunnel junctions leveraging these improvements have been fabricated.

ADVANTAGES

- Eliminates the need for a TCO or silver mirror
- Easy wide scale adoption of sputter deposition tools
- Reduction of excess magnesium in the fabrication of III-nitride junctions
- Fabrication of III-nitride tunnel junction devices using MOCVD for growth

APPLICATIONS

- LEDs
- Tunnel Junctions
- III-nitride devices

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,985,285	04/20/2021	2017-130

RELATED TECHNOLOGIES

- Contact Architectures for Tunnel Junction Devices
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide

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
- 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