Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
Tech ID: 29210 / UC Case 2018-250-0

BRIEF DESCRIPTION
An m-plane VCSEL with an active region that has thick quantum wells and operation in continuous wave.

BACKGROUND
Vertical-cavity surface-emitting lasers (VCSELs) are semiconductor laser diodes that emit light normal to the substrate. This design has many advantages over edge-emitting lasers and light-emitting diodes, such as low threshold current, circular mode profile, high-speed direct modulation, ability for single longitudinal mode operation, and two-dimensional arraying capability. As opposed to arsenide and phosphide-based devices, electrically-injected III-nitride VCSELs have been relatively difficult to create, and only eight research groups have successfully demonstrated these devices in the past decade. While most of the reports have been on c-plane, m-plane VCSELs have been demonstrated and have many advantages, such as lack of the quantum confined Stark effect, higher material gain, and anisotropic gain that leads to 100% polarization ratio. However, m-plane VCSEL devices have not been able to achieve continuous wave operation.

DESCRIPTION
Researchers at the University of California, Santa Barbara have created an m-plane VCSEL with an active region that has thick quantum wells and operation in continuous wave. This is the first report of a VCSEL capable of continuous wave operation. Thicker quantum wells (QWs) are possible on semipolar of nonpolar m-plane GaN, in contrast with standard c-plane GaN. These devices have improved thermal performance and a longer cavity length.

ADVANTAGES
- III-nitride VCSEL with continuous wave operation
- 100% polarized VCSEL emission

APPLICATIONS
- VCSELs
- AR/VR
- High-resolution displays
- LiFi
- Visible wavelength LIDAR

PATENT STATUS

<table>
<thead>
<tr>
<th>Country</th>
<th>Type</th>
<th>Number</th>
<th>Dated</th>
<th>Case</th>
</tr>
</thead>
</table>

RELATED CASES
2018-250-0

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
- Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
- Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
- Nonpolar (Al, B, In, Ga)N Quantum Well Design
- Improved Manufacturing of Semiconductor Lasers
- Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN

CONTACT
Sherylle Mills Englander
englander@tia.ucsb.edu
tel: View Phone Number.

INVENTORS
- DenBaars, Steven P.
- Forman, Charles A.
- Kearns, Jared A.
- Lee, SeungGeun
- Nakamura, Shuji
- Speck, James S.
- Young, Erin C.

OTHER INFORMATION
KEYWORDS
indfeat, VCSELs, LiFi, Augmented Reality, Virtual Reality, quantum wells, m-plane, semiconductors

CATEGORIZED AS
- Communications
- Other
- Energy
- Lighting
- Imaging
- 3D/Immersive
Etching Technique for the Fabrication of Thin (Al, In, Ga)N Layers
Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD
GaN-Based Thermoelectric Device for Micro-Power Generation
Growth of High-Quality, Thick, Non-Polar M-Plane GaN Films
Method for Growing High-Quality Group III-Nitride Crystals
Growth of Planar Semi-Polar Gallium Nitride
Defect Reduction of Non-Polar and Semi-Polar III-Nitrides
MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
Low Temperature Deposition of Magnesium Doped Nitride Films
Growth of Polyhedron-Shaped Gallium Nitride Bulk Crystals
Improved Manufacturing of Solid State Lasers via Patterning of Photonic Crystals
Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure
Phosphor-Free White Light Source
Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate
High Efficiency LED with Optimized Photonic Crystal Extractor
Packaging Technique for the Fabrication of Polarized Light Emitting Diodes
LED Device Structures with Minimized Light Re-Absorption
(In,Ga,AI)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
Oxyfluoride Phosphors for Use in White Light LEDs
III-V Nitride Device Structures on Patterned Substrates
Growth of Semipolar III-V Nitride Films with Lower Defect Density
Improved GaN Substrates Prepared with Amphomothermal Growth
Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
Semipolar-Based Yellow, Green, Blue LEDs with Improved Performance
Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration
Photoelectrochemical Etching Of P-Type Semiconductor Heterostructures
Photoelectrochemical Etching for Chip Shaping Of LEDs
Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of Optically Pumped and Electrically Injected III-Nitride LEDs
Defect Reduction in GaN films using in-situ SiNx Nanomask
Semi-polar LED/LD Devices on Relaxed Template with Misfit Dislocation at Hetero-interface
Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping
High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)
Nonpolar III-Nitride LEDs With Long Wavelength Emission
Method for Growing Self-Assembled Quantum Dot Lattices
Method for Increasing GaN Substrate Area in Nitride Devices
Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) LiftOff Technique
Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaAl Alloys
Low-Droop LED Structure on GaN Semi-polar Substrates
Improved Fabrication of Nonpolar InGaN Thin Films, Heterostructures, and Devices
Growth of High-Performance M-plane GaN Optical Devices
Method for Enhancing Growth of Semipolar Nitride Devices
Transparent Mirrorless (TML) LEDs
Solid Solution Phosphors for Use in Solid State White Lighting Applications
Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
Planar, Nonpolar M-Plane III-Nitride Films Grown on Miscut Substrates
Low-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
High Light Extraction Efficiency III-Nitride LED
Tunable White Light Based on Polarization-Sensitive LEDs
Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
Improved Anisotropic Strain Control in Semipolar Nitride Devices
III-Nitride Tunnel Junction with Modified Interface
Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
Increased Light Extraction with Multistep Deposition of ZnO on GaN
Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
Contact Architectures for Tunnel Junction Devices
Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
Methods for Fabricating III-Nitride Tunnel Junction Devices
Multifaceted III-Nitride Surface-Emitting Laser
Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs
Wafer Bonding for Embedding Active Regions with Relaxed Nanostructures
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
Distributed Feedback Laser with Transparent Conducting Oxide Grating
Eliminating Plasma Damage for Beta-Phase Gallium Oxide Transistors
Retaining Injection Efficiency and Optical Properties of Laser Diodes with Built-in Polarization Fields
Laser Diode With Tunnel Junction Contact Surface Grating
III-Nitride Tunnel Junction LED with High Wall Plug Efficiency