Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Liftoff Technique

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BRIEF DESCRIPTION
A method to fabricate a flexible array of micro III-nitride devices, including but not limited to LEDs, detectors, and vertical-cavity surface-emitting lasers (VCSELs).

BACKGROUND
Today's commercially available III-nitride LEDs are made of thin films that are grown epitaxially on the c-plane on sapphire substrates. However, these films have high threading dislocation (TD) densities, which hinder the material quality and optical performance. To combat this problem, efforts have been made to grow thin films on bulk GaN substrates. These bulk substrates include various orientations, including the basal c-plane, nonpolar a-plane, m-plane families, and semipolar plane families. With the appropriate technique, micro III-nitride devices grown on bulk GaN substrates could lead to flexible arrays of these devices with broad applications.

DESCRIPTION
Researchers at UC Santa Barbara have created a method to fabricate a flexible array of micro III-nitride devices, including but not limited to LEDs, detectors, and vertical-cavity surface-emitting lasers (VCSELs). The method combines the epitaxy of III-nitride thin films, the flip-chip bonding of these thin films to a flexible submount, and the use of a photoelectrochemical (PEC) etch technique to separate the devices from the rigid substrate. The flip-chip bonding process involves wafer bonding the light emitting device structure and substrate so that the microLED films are in-between the host substrate and submount. The PEC etch technique allows the bulk GaN substrates to be reused in the fabrication process.

ADVANTAGES
- Flexible array of inorganic light-emitting devices
- Substrates can be recycled
- Reusing bulk GaN substrates is cost-effective

APPLICATIONS
- Solid state lighting systems for flexible displays and wearable electronics

PATENT STATUS

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<th>Type</th>
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<td>United States Of America</td>
<td>Published Application</td>
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ADDITIONAL TECHNOLOGIES BY THESE INVENTORS
- Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
- High Efficiency LED with Optimized Photonic Crystal Extractor
- Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
- Edge-Emitting Laser Diode with Via-Activated Tunnel Junction Contact
- 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
Gallium-containing MicroLEDs for Displays
High Speed Indium Gallium Nitride Multi-Quantum Well (InGaN MQW) Photodetector
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-183)
Internal Heating for Ammonothermal Growth of Group-III Nitride Crystals
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
Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
Phosphor-Free White Light Source
Volumetric Hole Injection with Intentional V-Defects
Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure
Low Temperature Deposition of Magnesium Doped Nitride Films
Transparent Mirrorless (TML) LEDs
Improved GaN Substrates Prepared with Ammonothermal Growth
Laser Diode With Tunnel Junction Contact Surface Grating
Optimization of Laser Bar Orientation for Nonpolar Laser Diodes
High Efficiency Semipolar AlGaN-Cladding-Free Laser Diodes
Method for Growing Self-Assembled Quantum Dot Lattices
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
Near-Infrared, Flip-Chip, TCO-Clad, InGaN Quantum Dot Laser Diode
Incorporating Temperature-Sensitive Layers in III-N Devices
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
MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
Reduced Dislocation Density of Non-Polar GaN Grown by Hydride Vapor Phase Epitaxy
Heterogeneously Integrated GaN on Si Photonic Integrated Circuits
(AI, In,Ga, B)N Device Structures
Reduction in Leakage Current and Increase in Efficiency of III-Nitride MicroLEDs
Methods for Fabricating III-Nitride Tunnel Junction Devices
3D Hole Injectors for InAlGaN Light-Emitting Diodes
Formation of Transparent Integrated MicroLED Displays
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
Growth of Semipolar III-V Nitride Films with Lower Defect Density
III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
In-Situ Methods Of Preventing Interfacial Impurities And Dry Etch-Induced Damage In Regrown III-Nitride Structures
Enhanced Hole Injection by P-Type Active Region and Lateral Injection in InAlGaN LEDs
Improved Manufacturing of Solid State Lasers via Patternning of Photonic Crystals
Solid Solution Phosphors for Use in Solid State White Lighting Applications
Multifaceted III-Nitride Surface-Emitting Laser
Tunable White Light Based on Polarization-Sensitive LEDs
Cleaved Facet Edge-Emitting Laser Diodes Grown on Semipolar GaN
III-Nitride VCSEL with a High Indium Content Active Region
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
Photoelectrochemical Etching for Chip Shaping Of LEDs
III-V Nitride Device Structures on Patterned Substrates
Hexagonal Wurtzite Type Epitaxial Layer with a Low Alkali-Metal Concentration
Method for Increasing GaN Substrate Area in Nitride Devices
Burying Impurities And Defects In Regrown III-Nitride Structures
Growth of Planar, Non-Polar, A-Plane GaN by Hydride Vapor Phase Epitaxy
Single or Multi-Color High Efficiency LED by Growth Over a Patterned Substrate
GaN-Based Thermoelectric Device for Micro-Power Generation
Limiting Strain-Relaxation in III-Nitride Heterostructures by Substrate Patterning
Improved Manufacturing of Semiconductor Lasers
LED Device Structures with Minimized Light Re-Absorption
Improved Light Extraction with Geometrically Tuned LED Arrays
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
Low-Cost Zinc Oxide for High-Power-Output, GaN-Based LEDs (UC Case 2010-150)
Suppression of Defect Formation and Increase in Critical Thickness by Silicon Doping
Wafer Bonding for Embedding Active Regions with Relaxed Nanostructures
Enhancing Growth of Semipolar (Al,In,Ga,B)N Films via MOCVD