Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure

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BRIEF DESCRIPTION

A method for locally controlling an electrical potential of a semiconductor structure or device, and thus locally controlling lateral and/or vertical photoelectrochemical (PEC) etch rates.

BACKGROUND

PEC etching uses above-bandgap illumination to generate carriers (specifically holes) needed to etch III-nitrides. The electrochemical potential of the semiconductor material surface relative to the electrolyte causes holes to be drawn toward the semiconductor-electrolyte interface in n-type (unintentionally-doped or doped) material, allowing them to participate in the electrochemical reactions necessary for material removal. Because the etching mechanism relies heavily on the absorption of incident light and the electrochemical potential of the semiconductor material relative to the electrolyte, PEC etching can be defect-selective, dopant-selective, and bandgap-selective. Most applications of PEC etching have pertained to vertical etching of the material, either through direct illumination of the material surface, or by illumination through a masking layer. However, specific descriptions of local control of the etch process through modifications of the electrochemical component of etching have not been presented. Previously published and patented techniques that apply to III-nitride PEC etching suffer from certain limitations.

DESCRIPTION

This invention describes a scheme for fabricating III-nitride semiconductor structures wherein a highly selective photo-induced etch is achieved through strategic modification of the local electrochemical potential of the semiconductor structure relative to the electrolyte. This is accomplished through:

- The suitable placement of electrically resistive (unintentionally-doped, doped, alloyed) or electron-blocking layers in the semiconductor structure.
- The selective placement of the cathode in PEC etching, wherein the cathode acts as a "channel" for the controlled collection of photo-generated electrons from the semiconductor layers with which it is in contact.
- The use of a suitable light source during PEC etching, which enables the photo-generation of electrons and holes in layers with bandgap energies lower than the energy of the incident light. The etch will not proceed without photo-induced carriers. The light source may be a laser or a broad-spectrum source with/without a filter.
- The use of a suitable electrolyte solution during PEC etching, wherein the concentration and type of electrolyte determines the etch rate and etch selectivity.

ADVANTAGES

PEC etching is a viable method for producing specific geometries in the III-nitride material system, forming three-dimensional structures that would be extremely challenging to produce with gas-phase etching processes or more standard wet chemical etching. The existence of a controlled three-dimensional etch process can give rise to numerous useful device geometries. Specifically, an undercut geometry is desirable in several applications including but not limited to microdisk resonators, air-gap DBRs, semiconductor membranes and cantilevers, electrical and optical apertures, and in substrate removal.

APPLICATIONS

- Bandgap-selective lateral etching

PATENT STATUS

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OTHER INFORMATION

KEYWORDS

PEC etching, indPEC, indssl

CATEGORIZED AS

- Engineering
- Semiconductors
- Design and Fabrication

RELATED CASES

2005-207-0
Additional Technologies By These Inventors

- Method for Improved Surface of (Ga,Al,In,B)N Films on Nonpolar or Semipolar Substrates
- Enhanced Optical Polarization of Nitride LEDs by Increased Indium Incorporation
- Edge-Emitting Laser Diode with Via-Activated Tunnel Junction Contact
- Backside-Illuminated Photoelectrochemical (Bipec) Etching
- Lateral Growth Method for Defect Reduction of Semipolar Nitride Films
- Flexible Arrays of MicroLEDs using the Photoelectrochemical (PEC) Liftoff Technique
- Vertical Cavity Surface-Emitting Lasers with Continuous Wave Operation
- 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
- Highly Efficient Blue-Violet III-Nitride Semipolar Laser Diodes
- Hybrid Growth Method for Improved III-Nitride Tunnel Junction Devices
- Phosphor-Free White Light Source
- 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 AIGaN-Cladding-Free Laser Diodes
- 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
- Method for Manufacturing Improved III-Nitride LEDs and Laser Diodes: Monolithic Integration of Optically Pumped and Electrically Injected III-Nitride LEDs
- 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
- Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- 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
- (Al, In,Ga, B)N Device Structures
- 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
- Growth of Semipolar III-V Nitride Films with Lower Defect Density
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- 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
- 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
- Improved Manufacturing of Semiconductor Lasers
- LED Device Structures with Minimized Light Re-Absorption
- Growth of Planar Semi-Polar Gallium Nitride
- UV Optoelectronic Devices Based on Nonpolar and Semi-polar AlInN and AlInGaN Alloys
- 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
- Enhancing Growth of Semipolar (Al,Ga,N) Films via MOCVD