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

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OTHER INFORMATION

KEYWORDS

PEC etching, indPEC, indssl

CATEGORIZED AS

- **Engineering**
- **Semiconductors**
  - Design and Fabrication

RELATED CASES

2005-207-0

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.

DESCRIPTION

Researchers at the University of California, Santa Barbara have developed 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 with:

- 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

- Forms three-dimensional structures that would be extremely challenging with conventional etching processes
- Simple and effective approach to achieving undercut geometry

APPLICATIONS

- Bandgap-selective lateral etching
- Substrate removal
- Semiconductor devices
- LEDs
- Laser Diodes

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	7,550,395	06/23/2009	2005-207

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- 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)
- Implantable Light Irradiation Device For Photodynamic Therapy
- 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
- 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
- High-Efficiency, Mirrorless Non-Polar and Semi-Polar Light Emitting Devices
- Method for Growing High-Quality Group III-Nitride Crystals
- Technique for the Nitride Growth of Semipolar Thin Films, Heterostructures, and Semiconductor Devices
- MOCVD Growth of Planar Non-Polar M-Plane Gallium Nitride
- 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
- 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
- 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

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