A Method To Lift-Off Nitride Materials With Electrochemical Etch

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BACKGROUND

Over the past few decades, III-nitride materials have advanced rapidly in the fields of optoelectronics and power devices, including light-emitting diodes (LEDs), lasers, and high-electron mobility transistors (HEMTs). These devices are major candidates for displays, augmented reality (AR) devices, and cellular base stations. However, because of its wurtzite crystal structure and its lattice mismatch with other types of conventional semiconductors, high-quality III-nitride films cannot be easily grown on Si, GaAs, or other commonly used low-cost substrates; instead, the growth of epitaxial III-nitride layers is typically done on lattice-matched bulk GaN substrates, or cost-effective Al2O3 or SiC substrates. Therefore, the transfer of III-nitride devices from growth substrates to carrier wafers is essential for heterogeneous process integration.

Some methods of laser lift-off (LLO) and chemical lift-off (CLO) have been explored and used for the III-nitride material system, but they are limited by their yields and application. More efficient and high-quality device lift-off and transfer methods for III-nitride materials have been sought for decades. Electrochemical (EC) etching is another major candidate for selective removal of III-nitrides by adopting an external voltage-bias-initiated oxidation process. Conductivity-selective EC etching, on the other hand, does not restrict the alloy compositions of the sacrificial layer, or the assistance of the light, which provides more flexibility in the device design process.

DESCRIPTION

Researchers at the University of California, Santa Barbara have formulated a method to lift off and remove thin-film nitride layers from the growth substrate. This innovative method deposits a sacrificial layer below or under the epitaxial nitride layers during the material growth; exposes the sacrificial layers; performs an electrochemical etch to fully etch away the sacrificial layer, allowing the epitaxial nitride layers to become separated from the growth substrate; and finally transfers the thin film nitride layers. The exposed surfaces of the removed nitride layers and remaining substrates are very smooth compared with other transfer methods and are ready for subsequent wafer processing, regrowth, or recycling. Additionally, this lift-off method offers minimal damage to the removed layers and is applicable to various types of substrate materials.

ADVANTAGES

- Can be applied to all types of III-nitride films grown on multiple types of substrate
- Does not damage removed films
- Low cost
- Can be incorporated into high throughput production environments

APPLICATIONS

- Optoelectronics
- Light-emitting diodes
- Lasers
- High-electron mobility transistors
- Displays
- Augmented reality devices
- Cellular base stations

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OTHER INFORMATION

KEYWORDS

nitride, electrochemical etch, electrochemical, nitride layers, optoelectronics, light-emitting diodes, diodes, lasers, displays

CATEGORIZED AS

- **Optics and Photonics**
- All Optics and Photonics

RELATED CASES

2025-344-0

PATENT STATUS

Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- 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
- Enhanced Light Extraction LED with a Tunnel Junction Contact Wafer Bonded to a Conductive Oxide
- Methods to Produce and Recycle Substates for III-Nitride Materials with Electrochemical Etching
- Improved Reliability & Enhanced Performance of III-Nitride Tunnel Junction Optoelectronic Devices
- (In,Ga,Al)N Optoelectronic Devices with Thicker Active Layers for Improved Performance
- Thermally Stable, Laser-Driven White Lighting Device
- III-Nitride Tunnel Junction LED with High Wall Plug Efficiency
- Novel Multilayer Structure for High-Efficiency UV and Far-UV Light-Emitting Devices
- High-Intensity Solid State White Laser Diode
- Nitride Based Ultraviolet LED with an Ultraviolet Transparent Contact
- A Wafer-Scale, Low Defect Density Strain Relaxed Template for III-Nitride-Based High Efficiency and High-Power Devices
- High-Efficiency and High-Power III-Nitride Devices Grown on or Above a Strain Relaxed Template
- III-Nitride Based VCSEL with Curved Mirror on P-Side of the Aperture

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