Cascaded Nickel Hard Mask (#8790)

Scalable, consistent method using plasma etching to create deep mesas for high-power devices

This technology is a novel method to protect the semiconductor regions of power devices during fabrication in order to overcome the damage that often occurs during the plasma etching process. Georgia Tech's approach, which is suitable for the formation of the deep vertical mesas necessary for many high-power devices, addresses damage caused by plasma etching by utilizing a combination of a cascaded e-beam deposition and sputtering of nickel to form a cascaded nickel hard mask.

The robust nickel hard mask can withstand the plasma etching for the length of time necessary to protect the semiconductor regions underneath the mask without adhesion issues found in other thick metal mask approaches, and without forming chemical alloys that damage the semiconductor intended to be protected. The combination of the hard mask technology and lithography is a scalable method that has the potential to increase the speed and consistency of production of commercial high-power electronic and optoelectronic devices.

See also:
#8789, "Thin Current Spreading Layers Improve Breakdown Performance"
#8810/#8666/#8786, "Metal Modulated Epitaxy Grown Be-Doped AlN Films and Layered Films"

Benefits/Advantages

- **Substantially deeper etches**: Because a very thick metal mask can be created, a wide range of µm features can be etched in a variety of III-Nitride semiconductors, allowing for extremely high voltage devices that require thicker layer structures
- **Robust**: This method has demonstrated highly consistent and effective protection against the kind of damage that is typical with standard fabrication methods
- **Scalable**: The nickel hard mask with cascaded e-beam evaporation and sputtering metal deposition method can readily be applied to the large-scale production of electronic devices
- **Cost-effective**: By reducing the breakage and damage that is common in the production of high-power electronic devices, this method has the potential to greatly reduce the high costs of lost labor and wasted materials

Potential Commercial Applications

- Production of electronic devices
    - Optoelectronic devices

Background/Context for This Invention

Many emerging high-power power devices require large, multiple micron-deep mesa structures that are typically etched by a plasma process, which necessitates masks to protect regions from the aggressive plasma-etch. Unlike small-depth mesas that can use thin masks, many high-density metals used for mesa protection experience significant stresses and adhesion issues when deposited in thicker layers suitable for the protection of etched thick mesas. Additionally, some forms of metal masks alloy with the semiconductor they are designed to protect, creating substantial damage and potential contamination when the mask is removed in later processing steps. The Georgia Tech innovation alleviates these difficulties.

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Patent/IP Information

U.S. Application Filed

Publications

Cascaded Ni Hard Mask to Create Chlorine-Based ICP Dry Etched Deep Mesas for High-Power Devices, Semiconductor Science and Technology, November 2021

Substantial P-Type Conductivity of AlN Achieved via Beryllium Doping, Advanced Materials, September 2, 2021

Realization of homojunction PN AlN diodes, Journal of Applied Physics, May 2, 2022

For more information about this technology, please visit:
https://licensing.research.gatech.edu/technology/cascaded-nickel-hard-mask