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Plasma-Based Edge Terminations for GaN Power Devices

Background

Due to GaN's large bandgap, high breakdown electric field (Eb), and large Baliga's figure of merit (BFOM), GaN-based power electronics have attracted interest for high-voltage, high-power, and efficient power conversion applications. High-voltage power diodes often demand termination techniques to mitigate the premature breakdown at the junction edge. Mesa etching is one of the most commonly used methods to terminate and/or isolate high-voltage devices. However, this method can require complex fabrication processes, induce etching damage, increase the device capacitance, and cause reliability issues. Another popular method uses ion implantation to form a high-resistivity layer at the device edge by inducing mid-gap and/or compensating defects. After years of development, this method has been widely used in SiC power diodes but is far from mature for GaN applications. Postimplantation thermal annealing requires a very high-temperature (~1500 °C) that can cause decomposition of GaN, detrimental defects, and surface degradation, resulting in unreliable device performance and increased fabrication costs.

Invention Description

Researchers at Arizona State University have developed the first implementation of a hydrogen-plasma based edge termination technique (HPET) for GaN power devices. Edge terminations are critical for high-voltage power devices to avoid premature breakdown at the device edge. GaN power devices fabricated with HPET have seen significant improvements in reverse leakage currents and breakdown voltages. This edge termination process has been demonstrated to be reliable, low-temperature (~400 °C), thermally stable, CMOS-compatible, low-damage, cost-effective, and easy-to-implement.

Potential Applications

- Power conversion
- Power electronics

Benefits and Advantages

- Dramatically increases breakdown voltage and reduces leakage currents
- Features low-temperature processing which preserves GaN quality
- Compatible with commonly used Inductively Coupled Plasma Etching (ICP) tools, significantly reducing cost compared with ion implantation
- Simple fabrication does not require additional photolithographic steps

Related Publication 1

Related Publication 2

Research Homepage of Professor Yuji Zhao