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To cite this version:

Vishwajeet Maurya, Julien Buckley, Helge Haas, Mohamed Reda Irekti, Matthew Charles, et al.. Influence of Fluorine implantation on the electrical characteristics of GaN-on-GaN vertical Schottky and P-N diodes. E-MRS 2022, Sep 2022, Varsovie, Poland. cea-03968026

HAL Id: cea-03968026

https://cea.hal.science/cea-03968026v1

Submitted on 1 Feb 2023

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Influence of Fluorine implantation on the electrical characteristics of GaN-on-GaN vertical Schottky and P-N diodes

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Abstract

GaN-based power devices have been gaining popularity in recent years thanks to GaN properties such as wide bandgap, high electron mobility, and high breakdown field strength, allowing low Ron, and high-frequency operation. Lateral GaN devices, which are grown on a foreign substrate like Si and sapphire [1], have already been commercialized and have been able to achieve much better performance compared to their silicon counterparts. However, these devices are unable to achieve sufficiently high breakdown voltage (BV>1kV). One alternative to boost the breakdown voltage and lower R_{on} is to have vertical devices grown on a native GaN substrate. These devices still suffers from premature breakdown and high reverse leakage due to electric field crowding at the junction edge. This issue can be resolved by creating an effective edge termination either by using Mg implantation [2] to create a p-doped region or by alternate species implantation by Nitrogen [3] or Argon [4] to create a resistive region at the junction edge. However, due to the difficulty in creating p-GaN by ion implantation due to compensation by Hydrogen and large activation energy of ~170 meV, alternate species of implantation is preferred. Fluorine ion implantation [5] is an attractive alternative as it can form a negative fixed charge owning to its highest electronegativity thus spread the electric field away from the contact and can also modulate the free charge carrier in GaN.

In this study, P-N and Schottky structures are fabricated using multi energy Fluorine implantation as an edge termination. The influence of the implant on the electrical characteristics is studied by varying the implant overlap beneath the contact. µ-Raman scanning of the device suggests a reduction in free charge concentration in the implanted region, and an increase in the built-in potential obtained through C-V measurements compared to the device with no implantation. The influence of implantation on the electrical characteristics (B-V, I-V, and C-V) is analyzed and TCAD simulations using Synopsys® Sentaurus™ are performed to help interpret the results.

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