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Impact of Substrate Quality on Vertical GaN-on-GaN Schottky and PiN Devices

M. Dagher¹, C. Sonnevile², D. Planson², V. Maurya³, J. Buckley³, M. Charles³, H. Rammouz³, N. Rochat³, E. Frayssinet⁴, Y. Cordier⁴, F. Bartoli⁴, G. Brémond¹ and J.M. Bluet¹

¹INSA Lyon, Ecole Centrale de Lyon, CNRS, Université Claude Bernard Lyon 1, CPE Lyon, INL, UMR5270, 69621, Villeurbanne, France

²INSA Lyon, Université Claude Bernard Lyon 1, Ecole Centrale Lyon, CNRS, Ampère, 69621, Villeurbanne, France

³CEA-Leti, Univ. Grenoble Alpes, F-38000 Grenoble, France

⁴Université Côte d'Azur, CNRS, CRHEA, F-06560 Valbonne, France

In recent years, vertical GaN-on-GaN devices have emerged as potential substitutes for conventional lateral power devices like GaN-on-Si, GaN-on-Sapphire and SiC devices. This promise is due to the vertical structure that offers a pathway to higher breakdown voltages and lower on-resistance allowing to fully benefit of the superior properties of GaN such as wide bandgap, high electron mobility, high critical field breakdown. Despite this potential, these devices face some challenges in terms of material quality, mainly structural defects which affects their electrical performance reliability, and overall efficiency.

This study investigates the effects of substrate quality on the characteristics of vertical GaN-on-GaN Schottky and PiN diodes, focusing on defects and its impact on device performance, using samples from two different manufacturers.

We studied vertical GaN Schottky and PiN structures grown on GaN substrates from two different providers (substrate "A" and substrate "B"). Cathodoluminescence (CL) and micro-Raman spectroscopy were realized in order to assess the existence of dislocation clusters, and stress and doping inhomogeneity. Our results indicate that samples grown on substrate "A" exhibited more clusters, greater inhomogeneity in stress and doping distribution, in comparison to those grown on substrate "B". These structural imperfections, revealed through 2D Raman mapping and CL, suggest that substrate "A" has a higher defect density. These defects may act as leakage pathways which will affect the device's efficiency and reliability. The electrical characterization via Deep Level Transient Spectroscopy (DLTS), I-V and Breakdown Voltage (BV) measurements will further elucidate the origins of these defects in both samples in respect with growth or technological process source and their impact on device performance.

In conclusion, the substrate quality of GaN-on-GaN devices is crucial in determining their performance. This research underscores the need for high-quality GaN substrates to fully leverage the material's superior properties for advanced electronic applications. Future work will focus on completing the electrical characterizations and exploring the relationship between physical characterization and device performance across different manufacturers.

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