High Performance and Stable Au-free AlGaN/GaN Lateral Power Diode on 200-mm Silicon Substrate

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Sponsorship: IMEC Industrial Affliation Program

The wide bandgap nature of GaN-based electronic devices and the high mobility and electron density of the 2-dimensional electron gas (2DEG) at the AlGaN/GaN heterointerface lead to a high power figure-of-merit (FOM) $BV^2/R_{ON,SP}$ and enable power conversion with higher efficiency.

The goal of this project is to realize high-performance AlGaN/GaN diodes on 8-inch silicon substrate with Au-free CMOS-compatible technology. The lateral AlGaN/GaN diode could be co-integrated with AlGaN/GaN high electron mobility transistor (HEMT) for compact and cost-effective power systems. Besides the performance requirements, the long term stability of the diode with temperature and bias conditions has to be investigated and optimized.

An AlGaN/GaN SBD architecture with gated edge termination (GET-SBD) was designed in Figure 1 and can be co-integrated with AlGaN/GaN HEMT by using only one extra lighographic step. Three orders of magnitude leakage reduction has been realized in GET-SBD comparing with the conventional SBD. A further leakage reduction was demonstrated by optimizing the anode metallization scheme (Figure2). By evaluating the BV versus L_{AC} of the diode, we identified that buffer parasitic leakage dominates the high-voltage characteristics of the GET-SBD. The optimized GET-SBD power diodes with anode width of 10-mm deliver ~4 A at 2 V and show a median leakage of 1.3 μA at 25 °C and 3.8 μA at 150 °C. The high performance GET-SBD demonistrates a power FOM as high as 2.5 GW/cm^2.

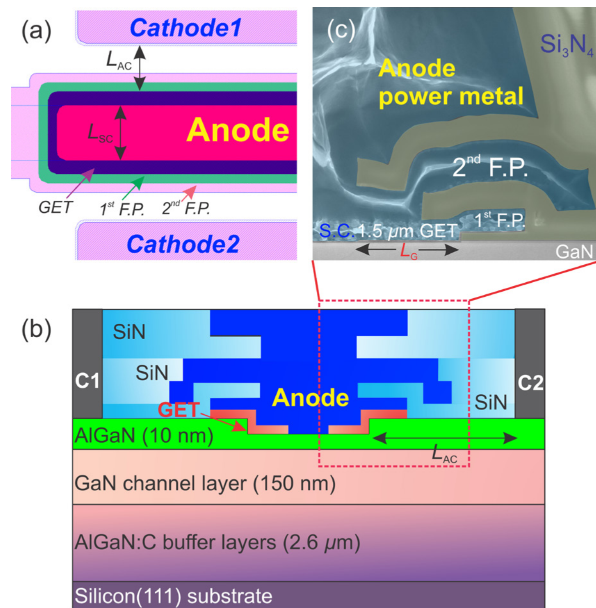

Figure 1: (a) Layout design of AlGaN/GaN Schottky Barrier Diode with Gated Edge Termination (GET-SBD) and two-level field plates. (b) Cross-sectional schematic of AlGaN/GaN GET-SBD on silicon. (c) SEM image of the anode region in the AlGaN/GaN GET-SBD.

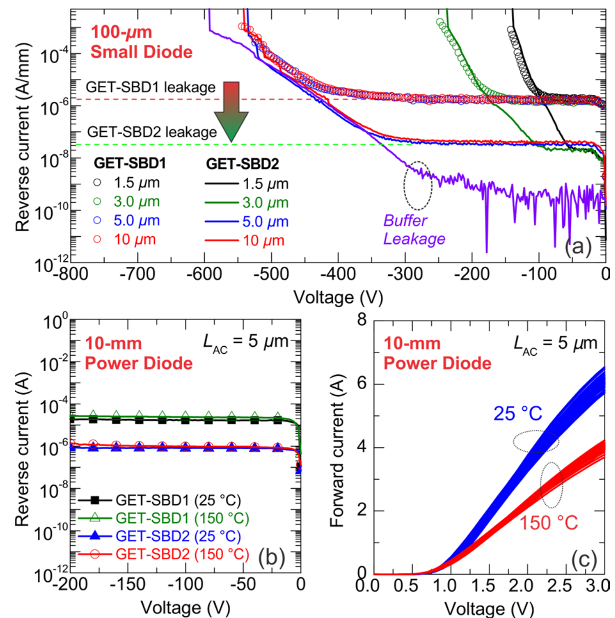

Figure 2: (a) Breakdown characteristics of the GET-SBD1 and GET-SBD2 with a variation of spacing L_{AC}. (b) Off-state characteristics of GET-SBD1 and GET-SBD2 power diodes measured at 25°C and 150°C. (c) Forward characteristics of power diodes at 25°C and 150°C.

FURTHER READING

› S. Lenci, B. De Jaeger, L. Carbonell, J. Hu, G. Mannaert, D. Wellekens, S. You, B. Bakeroot, S. Decoutere, "Au-Free AlGaN/GaN Power Diode on 8-in Si Substrate With Gated Edge Termination," *IEEE Electron Device Letters*, vol. 34, no. 8, pp. 1035-1037, Aug. 2013.
› J. Hu, S. Stoffels, S. Lenci, B. Bakeroot, B. De Jaeger, M. Van Hove, N. Ronchi, R. Venegas, H. Liang, M. Zhao, G. Groeseneken, S. Decoutere, "Performance Optimization of Au-free Lateral AlGaN/GaN Schottky Barrier Diode with Gated Edge Termination on 200-mm Silicon Substrate," *IEEE Transaction on Electron Devices*, to be published.