

Fabrication and Electrical Characterization of SiC Schottky Barrier Diodes

Su Jin Kim, Jang Ho Ha, Hyun Bin Kim, Young Soo Kim, Han Soo Kim*

Korea Atomic Energy Research Institute, 29 Geumgu-gil, Jeongeup-si, Jeollabuk-do, 56212, Republic of Korea

*Corresponding author: khs00@kaeri.re.kr

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1. Introduction

4H-silicon carbide (4H-SiC) has become one of the most promising semiconductor materials for medium- and high-voltage power electronics owing to its wide bandgap of 3.26 eV, high critical electric field of 2.5 to 3.0 MV/cm, and excellent thermal conductivity of 4.9 W/cm·K [1-3]. These intrinsic material properties enable low specific on-resistance, high blocking capability, and superior thermal stability, making 4H-SiC power devices well suited for high-efficiency power conversion systems such as electric vehicles, renewable energy systems, and industrial power converters. Furthermore, the excellent thermal stability and radiation tolerance of 4H-SiC make it a promising material for radiation detectors in nuclear and fusion energy systems, where high-temperature and high-radiation environments demand stable and reliable detector operation [4].

Among various SiC devices, the Schottky barrier diodes (SBDs) are widely used in high-frequency power conversion systems owing to their majority-carrier operation, which enables negligible reverse-recovery current and low switching losses. [5]. Device performance is primarily determined by the optimization of the epitaxial structure, Schottky contact, and edge termination design, requiring careful trade-offs between forward conduction characteristics and reverse blocking capability.

In this study, 1.2 kV 4H-SiC SBDs were fabricated on 4-inch wafers using a standard SiC device fabrication process. The fabricated devices were electrically characterized using current-voltage (I-V) measurements to evaluate the forward conduction characteristics, reverse leakage current, and blocking capability.

2. Methods and Results

Fig. 1 illustrates the schematic cross-sectional structure of the fabricated 1.2 kV 4H-SiC SBD. The devices were fabricated on commercially available 4-inch n-type 4H-SiC wafers with a 10- μ m-thick n-type epitaxial drift layer doped to approximately 5.93×10^{15} cm⁻³. The active area of the fabricated devices was 3.35 mm². The fabrication process began with standard RCA cleaning followed by sacrificial thermal oxidation to remove surface damage and contaminants introduced

during wafer processing. To realize a high-voltage blocking capability, multiple floating field limiting rings (FLRs) were employed as the edge termination structure. The FLRs were defined by photolithography and formed through multiple Al ion implantation processes. Dopant activation and implantation damage recovery were subsequently carried out by high-temperature annealing at 1700 °C in an Ar ambient using a carbon capping layer to suppress surface degradation during the annealing process. After removing the carbon cap, a SiO₂ passivation layer was deposited to reduce surface leakage current and protect the device surface. The backside ohmic contact was formed by depositing Ni followed by rapid thermal annealing at 1000 °C, and Ti/Ni metallization was subsequently deposited. Finally, the Schottky contact metal was deposited and patterned on the front surface to complete the SBD fabrication.

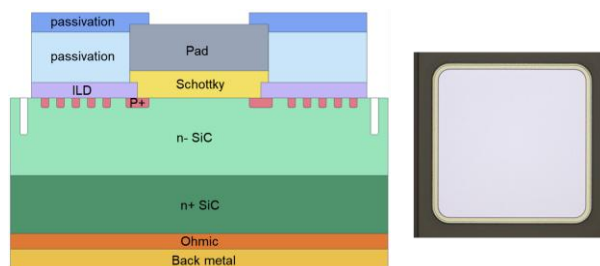


Fig. 1. Cross-sectional schematic and optical image of the fabricated 4H-SiC SBD chip.

The electrical characteristics of the fabricated devices were evaluated using I-V measurements. Under forward bias conditions, the fabricated SBDs exhibited a forward voltage drop of approximately 1.3 V at a forward current of 5 A. At a forward voltage of 1.5 V, the current reached approximately 7.9 A, corresponding to a current density of approximately 235 A/cm². The forward current increased exponentially with increasing bias voltage, indicating excellent Schottky junction characteristics with low series resistance. Under reverse bias conditions, the fabricated devices exhibited a breakdown voltage exceeding 1.2 kV, defined at a reverse leakage current of 100 μ A. The measured reverse blocking characteristics demonstrate that the implanted multiple FLR termination effectively suppresses electric-field crowding at the device periphery, thereby enabling stable high-voltage operation without premature edge breakdown. These

results confirm that the device incorporating the optimized edge termination achieves reliable reverse blocking capability while maintaining favorable forward conduction characteristics.

3. Conclusions

In summary, 1.2 kV 4H-SiC SBDs were successfully fabricated using a conventional fabrication process with a FLR edge termination. The fabricated SBDs exhibited a forward voltage drop of approximately 1.3 V at 5 A and a reverse breakdown voltage of up to 1.2 kV. These results demonstrate the potential of 4H-SiC SBDs for power conversion and radiation detection applications in harsh environments.

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