

Packaging of 15 kV Silicon Carbide Half-Bridge Module Enabled by a Polymer Nano-Composite Field-Grading Coating

To propel medium voltage (MV) silicon carbide (SiC) power devices and modules in grid-tied applications, innovative packaging solutions are needed to improve module insulation without sacrificing thermal performance. Recent advances in nonlinear resistive field-grading offer a promising solution. The use of a nonlinear resistive field-grading coating at the triple-point (TP) inside a module can significantly reduce the electric field stress without increasing its thermal resistance. In a previous study, we measured the nonlinear electrical properties of a polymer nanocomposite (PNC) and showed its field-grading effectiveness as a coating for MV power module substrates. In this study, we applied the coating technology to make a 15 kV SiC MOSFET in a half-bridge module using aluminum nitride (AlN) direct-bond-copper (DBC) substrates with 1.0 mm thick ceramic.

Fig. 1 shows the layout of the 15 kV SiC MOSFET half-bridge module. It is made of a 50 mm x 50 mm AlN DBC substrate with an etched pattern for die-attach and electrical routing. The AlN thickness is 1.0 mm, which is considerably thinner than that of the state-of-the-art 10 kV module. All the TP edges on the substrate are coated by the PNC. For each module, two SiC MOSFETs are attached to the substrate by silver-sintering, and their source and gate pads are wire-bonded. The PD performance of the package was tested on smaller AlN DBC coupons with an etched pattern. PDIVs of the coupons with and without the polymer nanocomposite coating are shown in Fig. 2. The coated coupons had 85% higher PDIV than that of the uncoated. Two fabricated modules were tested for terminal-to-baseplate PD, and both survived for 1 minute without PD at 20 kV peak.

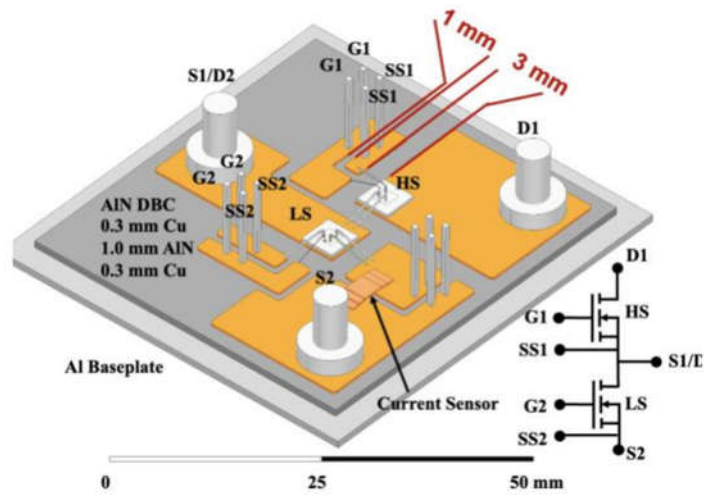


Fig. 1. Package design of the 15 kV SiC MOSFET half-bridge module and its equivalent circuit

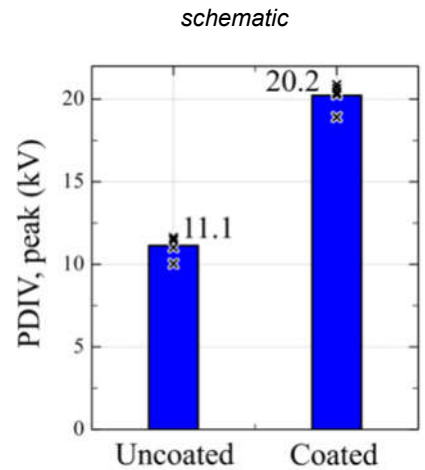


Fig. 2. Measured PDIVs of uncoated and coated AlN DBC test coupon