

Fabrication of large area >8 kV SiC GTO Thyristors with innovative anode-gate designs

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For efficient high-temperature and high-power electronics applications, the need for wide band-gap is important. Hybrid vehicles, aircraft, ships, industrial motor controls, and radiation hard applications, require high power switching devices. Currently Si-based devices are used for such application. Silicon Carbide (SiC, 3.2 eV band gap) show promising potential to replace Silicon as the material of choice because of its superior material properties. Other materials suitable to replace Silicon are Gallium Nitride, Aluminum Nitride or diamonds. To this day SiC is the most mature from the fabrication point of view. Currently the cost of wafers is decreasing while the size and quality is increasing. Single crystal 4 inch wafers with low defect densities are currently available for the fabrication of devices. The only product commercially available is the Schottky diode, it is projected that more devices will be available soon in few years.

MOS-based gate control is considered a necessity for the applicability of a switch to pulse-width modulation (PWM) circuits used in high voltage power conversion. Also, bipolar-mode switches offers low conduction losses in >10 kV SiC devices as compared to unipolar devices. Thyristor-based devices offer the lowest on-state drop due to high level of minority carrier injection into the low doped voltage blocking region.

This study is focused on the design and fabrication of large-area 4.1x4.1 mm and 8.2x8.2 mm, 8.1 kV 4H-SiC Gate Turn Off (GTO) Thyristors. The anode and gate fingers of Thyristors were designed with involute, cellular or hexagonal patterns. Forward blocking voltages as high as 8106 V and On-state voltage drop (V_{on}) and differential specific on-resistance ($R_{on,sp}$) as low as 3.8 V and $6 \text{ m}\Omega\text{-cm}^2$ at 100 A/cm^2 were measured on these devices. About 59% of 4.1 x4.1 mm and 29% of 8.2x8.2 mm Thyristors blocked voltages in excess of 6 kV. Detailed investigations revealed the impact of different anode/gate finger geometries on the device characteristics. Preliminary pulsed power characterization of the GTO Thyristors was also performed.