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Automotive SiC diodes

Automotive applications, such as onboard charger systems, can benefit from the increased efficiency that results from the use of the latest SiC technology

As the world's first supplier of SiC discrete power, Infineon has accumulated a considerable market presence and more than 15 years of experience, which began with the introduction of the first SiC 600V Schottky diodes. The company delivers highly reliable, industry-leading SiC devices. The latest entry to this portfolio is the Automotive Gen-5 650V Schottky diode, qualified according to AEC-Q101.

The new diode offers a number of benefits for automotive designers: no reverse recovery charge; no forward recovery; purely capacitive switching; 40-50% reduction in turn-on loss when switched in tandem with an IGBT; no voltage overshoots; switching losses independent from load current, switching speed and temperature; 20-30% higher output power in same form factor; reduced EMI; no need for snubber circuitry; reduced parts count; and high system reliability. The reduction of forward voltage ensures the lowest static losses over the entire load range during operation. In addition, a massively increased surge current capability provides high reliability during surge current events.

Figure 3 shows a schematic representation of the new SiC Schottky diode. Besides the front side metal and the Schottky contact, two other layers are represented – the drift layer, which provides the blocking capability during reverse voltage application, and the SiC substrate, which provides mechanical stability and the back side metal. The current flow direction during forward biased operation is from top to bottom. Infineon thin-wafer technology reduces the substrate's thickness, so the diode's overall resistance is reduced, thus lowering the forward voltage when the diode is conducting. Moreover, the new SiC generation presents a lower dependency of the forward voltage on temperature.

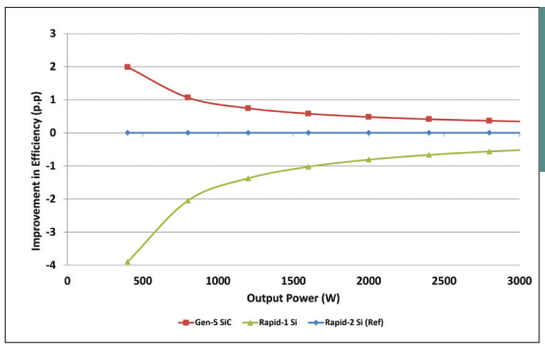

Figure 1: SiC diodes improve the efficiency compared with related Si diodes

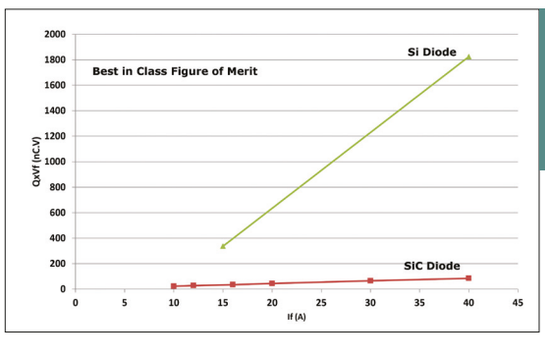

Figure 2: Comparison of the Figure of Merit (FoM = Qc x Vf) between Si and SiC diodes

The epitaxial layer of the Schottky diode additionally contains p-doped regions labeled as p+. At low (normal) current densities, the current flows through the Schottky regions (unipolar current). For surge currents, for example the in-rush current to a capacitor during the turn-on of the system, the p+ regions become active and provide additional total current-carrying capability. As a result, the diodes behave as a Schottky diode in normal operation and as a pn diode in surge operation.

As a result of the reduced forward voltage and the absence of reverse recovery, SiC diodes yield a considerably lower figure of merit, or FoM (Qc x Vf, Figure 2), compared with Si diodes. Lower FOM implies lower power losses and therefore better electrical performance. This translates to higher benefits at the system level.

Taking a classical boost PFC (power factor correction) topology in an automotive onboard charge application as an example, Figure 1 shows the improvement in efficiency in comparison to Si diodes (Rapid-1 and Rapid-2) based on the following conditions: switching frequency = 65kHz and continuous conduction mode. The replacement of Si diodes in classical boost systems with SiC diodes results in increased efficiency of up to 2 percentage points compared with the Rapid-2 Si diode, clearly demonstrating the efficiency benefits of SiC diodes.

Compared with Si diodes, the automotive SiC diodes do not show reverse recovery and forward recovery losses, just a small amount of capacity charge losses. This leads to considerably lower switching losses and increased efficiency. Typical automotive applications that benefit from these advantages include PFC systems in onboard charger systems.

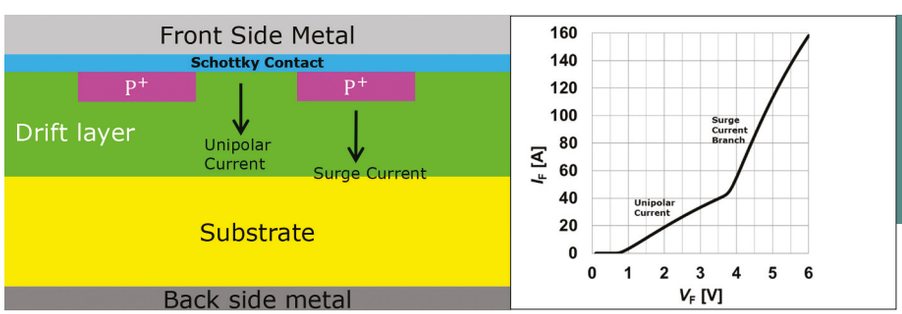

Figure 3: Principle structure of the CoolSiC Gen 5 diodes: Improved surge capability based on the p+ islands