Current Status of SiC Materials and Devices for use in Power Applications

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SiC semiconductor technology has entered a stage of rapid market adoption in the last few years. The reasons for this are continuous cost reduction due to improved material defect densities and cost, increasing volume, the high number of field hours amassed that show SiC to be highly reliable, and the realization that SiC can reduce overall system cost despite having a higher component cost than silicon devices.

The bulk of SiC power device manufacturing has now migrated to the use of 150 mm substrates. This has allowed obvious cost reduction, but also the access to a more modern and automated tool set that has further increased device yields. While the micropipe defect has largely become a minor yield detractor, current efforts are more focused on reducing the number of basal plane dislocation defects in SiC substrates, and on achieving improved wafer shape and surface polish. As the market grows further, the push to 200 mm substrates is inevitable, and these have been demonstrated in R&D already.

SiC power MOSFETs are now driving the market growth, whereas much of the market was based on SiC Schottky diodes in the past. SiC MOSFETs have been adopted in a variety of markets such as solar inverters, industrial power supplies, and EV on-board and off-board chargers.

Going forward, the rapid adoption of SiC will be driven by the equally rapid adoption of Battery Electric Vehicles (BEVs). SiC is now being targeted for use in the inverter for the drive train of electric vehicles. This is because SiC offers a 7-10% improvement in efficiency for the motor drive, which results in either extended range for the vehicle for a given battery charge, or a reduction in the battery pack required to go a certain distance. A large number of automotive OEMs now have SiC targeted for incorporation into their EV drives.

In order to enable these EV drive applications, the power modules to be used require large area SiC MOSFET chips delivering current in the range of 80-100 Amps per chip. A variety of chips ranging from 650 V to 1200 V in this amperage range will be discussed. These chips were designed for the unique requirements of the power modules they will go into. Some power module design considerations will also be discussed, that allow one to take full advantage of the SiC performance versus the traditional Si-based power modules.