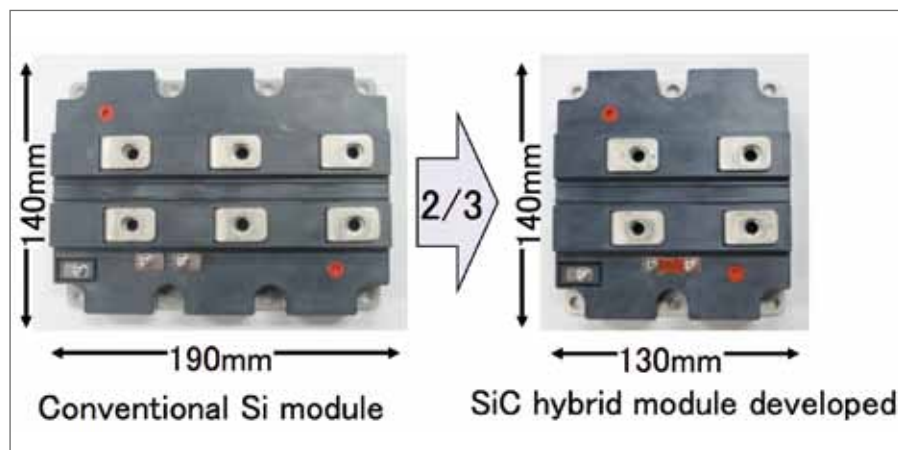


Current rail inverters are mainly designed for a high voltage of 1500V from overhead wires and therefore downsizing of high voltage power modules is important. Hitachi has developed a compact 3.3kV/1200A hybrid module for rail car inverters having a high voltage resistance of 3.3kV using SiC. The hybrid module developed combines 3.3kV SiC-SBDs (Schottky barrier diode) and Si-IGBTs. To achieve a compact size module, Hitachi optimized both the SiC-SBD structure and the Si-IGBT device characteristics taking full advantage of device, circuit and loss simulations, and succeeded in reducing the module size to approximately two-thirds that of current Si modules.

In 2009, Hitachi developed 3kV-class SiC-SBDs which employ a JBS (Junction Barrier Schottky) structure that combines Schottky junctions with pn junctions, and mounted these in a power module, which led to the development of this compact SiC hybrid module for railcar inverters. Features of the technology developed are as below:

## SiC-SBD

To achieve a compact power module, it is necessary to pass a large current across the SiC-SBD which has a limited surface area. By employing the JBS structure which combines Schottky junctions and p-n junctions, both conduction loss and leakage current can be reduced. This effect was further enhanced by applying device simulation to optimize the



JBS structure successfully resulting in increased current per SiC-SBD surface unit area. Further, as the internal electric field of SiC is approximately 10 times that of Si, the optimal device edge structure was designed using device simulation to decrease the electric field around the device edge and assure the reliability required for rail cars.

## Si-IGBT

Si-IGBT device with trench gate structure was developed, whose cell size was one third of previous generation device, leading to 20% loss reduction. The device characteristics were optimized by applying circuit and loss simulation in rail application circuits.

The compact 3.3kV/1200A hybrid module with the size two-thirds that of conventional Si module and maximum operating temperature of 150°C, was fabricated combining the Si-IGBT and the SiC-SBD technologies.

Hitachi also developed SiC hybrid inverter for rail cars that is compatible with 1,500V DC overhead power supply using the compact hybrid module and lightweight oil-free capacitors. Size and weight of 40% smaller and lighter than current mainstream inverters, and 35% reduced power loss are successfully achieved.