SiC MOSFET with record power efficiency for 1200V-class power device

Extra region in source area controls series resistance, reducing short-circuit current and simplifying protection circuitry

At the International Conference on Silicon Carbide and Related Materials (ICSCRM 2017) in Washington DC (17–22 September), Tokyo-based Mitsubishi Electric Corp unveiled a silicon carbide (SiC) metal-oxide-semiconductor field-effect transistor (MOSFET) with what is believed to be record power efficiency for a 1200V-class power device.

Semiconductor power devices are key components of the power electronics equipment used in a wide range of applications such as home electronics, industrial machinery and railway trains. Mitsubishi Electric achieves high energy efficiency ratings by utilizing SiC MOSFETs, meeting the requirements for higher energy efficiency and reduced size that are essential in those fields.

Short circuits in power electronics equipment can cause large overcurrent flows into semiconductor power devices, which may lead to damage or failure. Excess current must therefore be interrupted as quickly as possible. Because the resistance of a SiC MOSFET is lower than that of a silicon device, any overcurrent tends to be large, resulting in a reduction in the short-circuit time (the length of time a device can

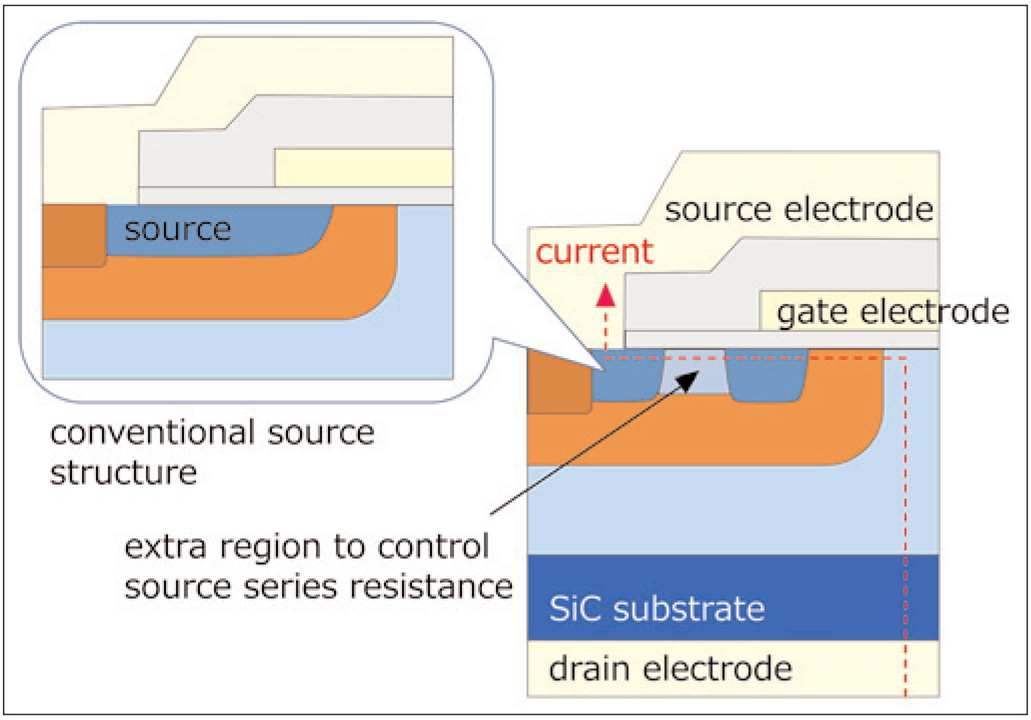

Figure 1. Cross-sectional schematic of the new SiC MOSFET structure.

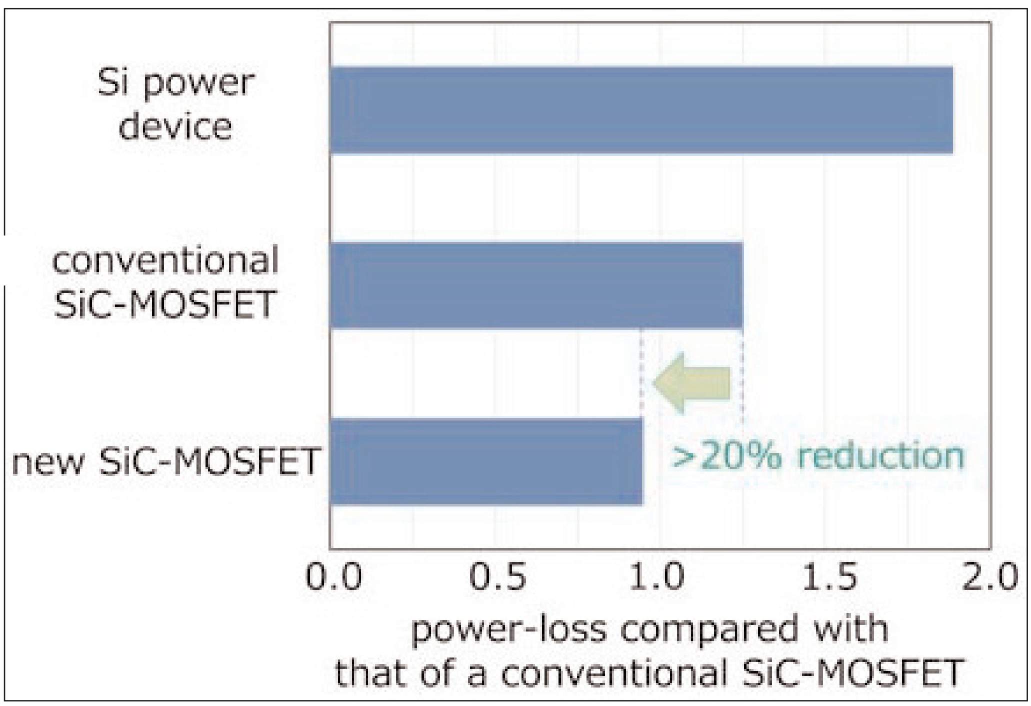

Figure 2. Reduction in power loss through adoption of the new structure.

withstand any overcurrent). To protect SiC MOSFETs from damage, overcurrent must be terminated more quickly than with a silicon device, usually by including special protection circuits.

There is also a trade-off between the short-circuit time and on-resistance. A long short-circuit time requires high on-resistance and a large chip size. Improvements in this trade-off have been in demand for a long time.

In conventional MOSFETs, the source area is formed as a single region. However, Mitsubishi Electric has introduced an additional region in the source area to control the source series resistance of the SiC MOSFET (see Figure 1). Adopting this structure reduces the incidence of excessive current flows caused by short circuits.

With a short-circuit time exceeding 8µs, Mitsubishi Electric's new device does not require a high-speed protection circuit to interrupt supply when excess current is detected. The structure of the new SiC power device reduces the short-circuit current as a result of the increased resistance resulting from the temperature rise induced by the short circuit, while at the same time keeping the on-resistance low at normal operating temperatures. As a result, on the basis of the general short-circuit time used for silicon power semiconductor devices, the on-resistance of the SiC MOSFET (at room temperature) is reduced by 60% compared with regular silicon power semiconductor devices and by 40% compared with conventional SiC MOSFET devices, while power loss is reduced by more than 20% (see Figure 2).

This technology can hence improve the trade-off between short-circuit time and on-resistance. As a result, a SiC MOSFET with the new structure can simultaneously offer high reliability, high energy efficiency and reduced size.

Due to the long short-circuit time precluding the need for special protection circuitry, the simplified circuit design allows the technology to be applied across SiC MOSFETs with various ratings for blocking voltage. Also, established circuit technology (used to protect silicon power semiconductor devices from short-circuit damage) can hence be applied to SiC MOSFETs without any need for modification. Mitsubishi Electric says that this guarantees easy implementation of protective functionality in power electronics equipment using SiC MOSFETs.

The firm says that its development teams will further refine the new device, aiming to make it available commercially from 2020. ■

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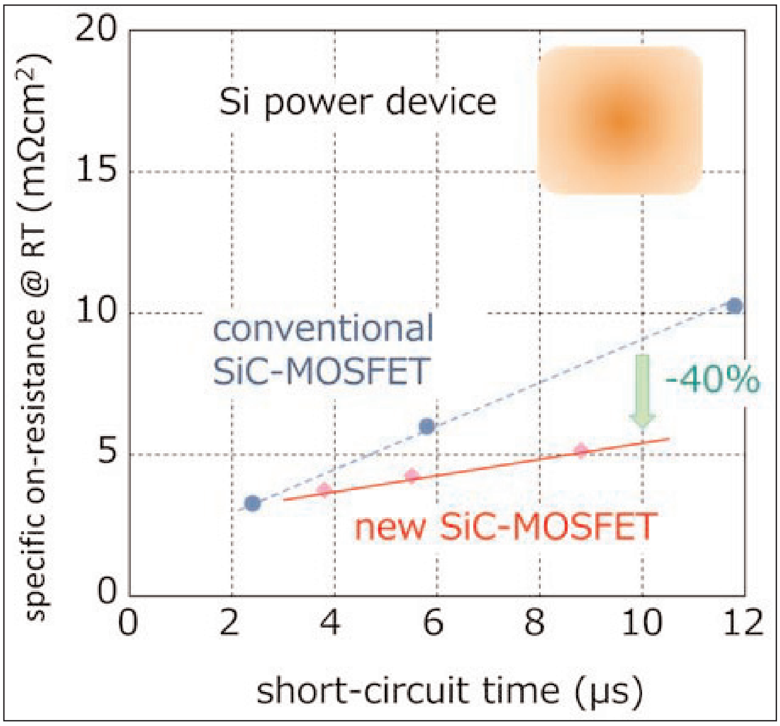

Figure 3. On-resistance at room temperature versus short-circuit time.