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Mitsubishi Electric Develops SiC Power Device with Record Power Efficiency

Will help improve the reliability and energy efficiency of power electronics equipment used in fields ranging from home electronics to industrial machinery

TOKYO, September 22, 2017 – Mitsubishi Electric Corporation (TOKYO: 6503) announced that it has developed a silicon carbide (SiC) power device with what is believed to be the world's highest power efficiency* in a device of its type. The newly-developed unit is designed to be installed in power modules, and does not require a high-speed protection circuit to interrupt supply when excess current is detected. The new device will help improve the reliability and energy efficiency of power electronics equipment used in a wide range of applications such as home electronics, industrial machinery and railway operation.

* According to Mitsubishi Electric research, at the time of this announcement the new SiC device had the world's highest power efficiency rating of any 1200V-class power device with a short-circuit time exceeding 8 µs.

Mitsubishi Electric's development of the new SiC device was first revealed at the 2017 International Conference on Silicon Carbide and Related Materials (ICSCRM 2017), held in Washington, D.C., September 17–22, 2017.

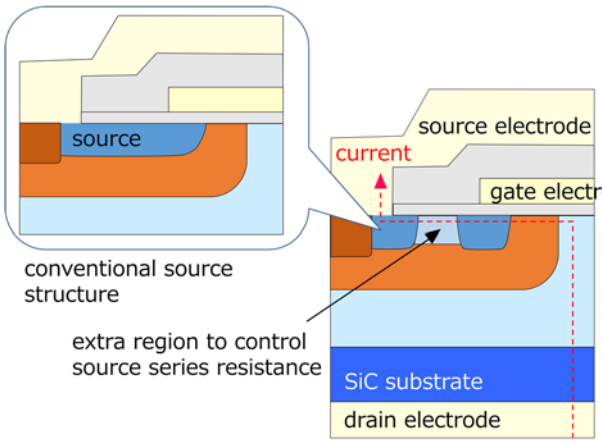

Fig. 1: Cross-sectional view of the newly-developed SiC-MOSFET

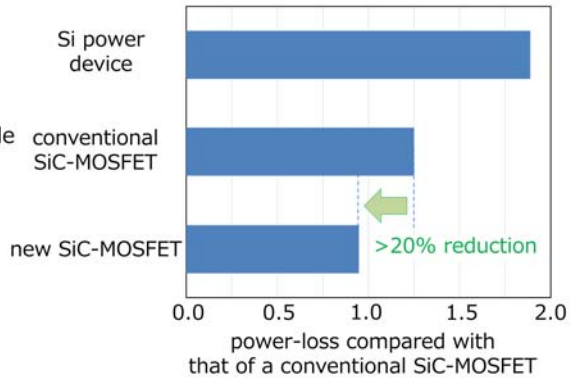

Fig. 2: Reduction of power loss through adoption of the newly-developed structure

The superior reliability and efficiency of the new device is the result of a new proprietary source structure. In conventional metal-oxide-semiconductor field-effect transistors, known as 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 fig. 1). Adopting this structure reduces the incidence of excessive current flows caused by short circuits. As a result, on the general short-circuit time used for Si power semiconductor devices, the on-resistance of the SiC-MOSFET is reduced by 40 percent at room temperature, and power loss by more than 20 percent (see fig. 2), compared to conventional SiC-MOSFET devices.**

** The term "on-resistance" refers to one of the characteristic values of a semiconductor power device and is quoted as a product of device area and its resistance. The on-resistance value falls as the size or resistance of a device is reduced. The value of 40 percent was obtained by comparing the on-resistance of the new device with that of our conventional 1200 V SiC-MOSFET.

A simplified circuit design allows the technology to be applied across SiC-MOSFETs with various voltage ratings. Tried and tested circuit technology is used to protect silicon components from damage in the event of short-circuits, and can be applied to existing SiC-MOSFETs without any need for modification. This guarantees easy implementation of protective functionality in power electronics equipment using SiC-MOSFETs.

Future Development

Mitsubishi Electric's development teams will further refine the new device, aiming to make it available commercially from the year 2020.

Background

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 as semiconductor power devices, 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 of the device. In order to prevent this, any excess current must be interrupted as quickly as possible. The "short-circuit time" is the length of time a device can withstand any overcurrent. Because the resistance of a SiC-MOSFET is lower than that of a Si device, any overcurrent tends to be large, resulting in a reduction of the short-circuit time. In order to protect SiC-MOSFETs from damage, overcurrent in these devices has to be terminated more quickly than with a Si device. This is usually achieved by the inclusion of special protection circuits for SiC-MOSFETs.

There is additionally 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.

The structure of the newly-developed SiC power device reduces the short-circuit current by the increased resistance resulting from temperature rise induced by the short circuit, at the same time keeping the on-resistance at low levels at normal operating temperatures. This technology can improve the trade-off between short-circuit time and on-resistance. As a result, a SiC-MOSFET equipped with the newly-developed structure can simultaneously offer high reliability, high energy efficiency and reduced size.

Details

1) Achievement of high reliability and efficiency by means of new source structure

A new structure for controlling the source resistance of a SiC-MOSFET has been developed by the use of the source structure comprising various parts. At similar levels of on-resistance, the new device allows the kinds of large short-circuit currents that may lead to device failure to be suppressed, resulting in extension of the short-circuit time of the device.

On the basis of the general short-circuit time used for Si power semiconductor devices, on-resistance in the new device is 60 percent lower than that of regular Si power semiconductor devices and 40 percent lower than that of a SiC-MOSFET with a conventional structure (see Fig. 3).

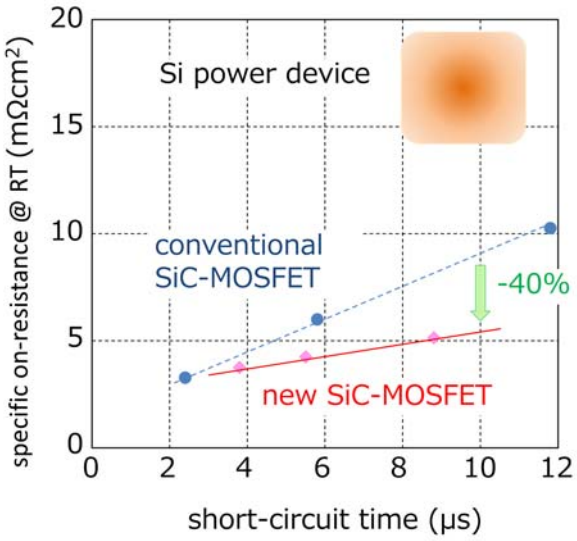

Fig. 3: On-resistance at room temperature versus short-circuit time

2) Simplification of circuit design

In the field of power electronics equipment, a long short-circuit time allows for a less complex circuit design, which enhances reliability. The newly-developed device can be deployed in SiC-MOSFETs with various blocking voltages, and easily operated with the existing short-circuit protection circuits used for Si power semiconductor devices.

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About Mitsubishi Electric Corporation

With over 90 years of experience in providing reliable, high-quality products, Mitsubishi Electric Corporation (TOKYO: 6503) is a recognized world leader in the manufacture, marketing and sales of electrical and electronic equipment used in information processing and communications, space development and satellite communications, consumer electronics, industrial technology, energy, transportation and building equipment. Embracing the spirit of its corporate statement, Changes for the Better, and its environmental statement, Eco Changes, Mitsubishi Electric endeavors to be a global, leading green company, enriching society with technology. The company recorded consolidated group sales of 4,238.6 billion yen (US$ 37.8 billion*) in the fiscal year ended March 31, 2017. For more information visit:
http://www.MitsubishiElectric.com

*At an exchange rate of 112 yen to the US dollar, the rate given by the Tokyo Foreign Exchange Market on March 31, 2017