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Mitsubishi Electric Develops Accurate Circuit Simulation Technology for SiC-MOSFETs

Will contribute to more efficient circuit designs for power converters

TOKYO, July 9, 2020 – Mitsubishi Electric Corporation (TOKYO: 6503) announced today that it has developed a highly accurate Simulation Program with Integrated Circuit Emphasis (SPICE) model to analyze the electronic circuitry of discrete power semiconductors. The technology is deployed in the company's "N-series 1200V" SiC-MOSFET* samples of which will begin shipping in July. The model simulates high-speed-switching waveforms almost as well as actual measurements, on a level of accuracy currently believed to be unmatched in the industry, which is expected to lead to more efficient circuit designs for power converters. Going forward, Mitsubishi Electric expects to add several temperature-dependent parameters to enable its SPICE model to work at high temperature. The company presented the new model** on July 8 at the International Conference on Power Conversion and Intelligent Motion (PCIM Europe 2020), which was held online on July 7 and 8.

* Silicon-carbide metal-oxide-semiconductor field-effect transistor

** Conference presentation: T. Masuhara, T. Horiguchi, Y. Mukunoki, T. Terashima, N. Hanano and E. Suekawa. "Development of an Accurate SPICE Model for a New 1.2 - kV SiC-MOSFET Device"

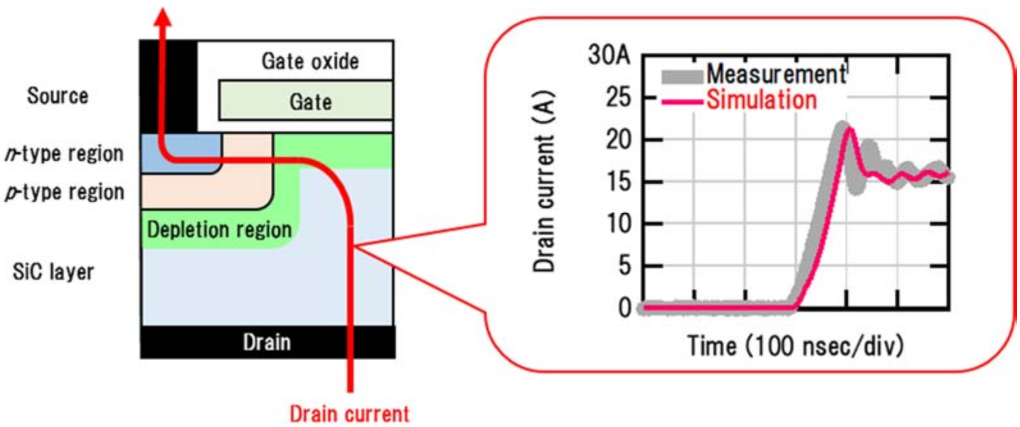

Fig. 1 Cross-sectional view of SiC-MOSFET (left) and example analysis of switching waveforms (right)
(*p*-type: SiC layer implanted with aluminum ions; *n*-type: SiC layer implanted with nitrogen ions)

Characteristics of SiC-MOSFET

The SiC-MOSFET controls the current (drain current) flowing from the drain electrode to the source electrode depending on the voltage that is imposed on the gate electrode (Fig. 2). The MOSFET has parasitic capacitances that accumulate charges and determine switching speed. When a voltage is applied to the electrodes of the device, the capacitance values change due to changes in distance between the layers that accumulate the positive and negative charge changes, resulting in changes in the switching speed. When the distance between layers decreases, the capacitance value increases and the switching speed decreases, and conversely, when the distance between layers increases, the capacitance value decreases and the switching speed increases.

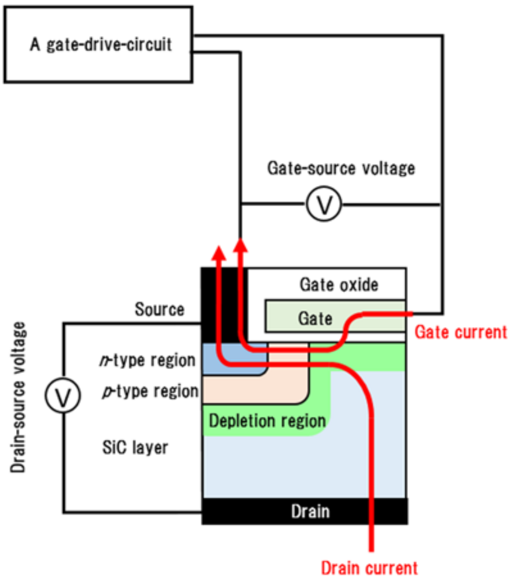

Fig. 2 Cross-sectional view of SiC-MOSFET

Key Features

1) ***Unique SPICE model enables efficient circuit design for power converters***

Mitsubishi Electric's unique SPICE model performs highly accurate simulations thanks to the incorporation of carefully evaluated voltage dependencies of the parasitic capacitances. High-precision simulations of current waveforms are possible during high-speed switching, which was not achievable with the previous model. For example, for turn-on switching in which the SiC-MOSFET switches from non-conducting to conducting, the simulated waveforms of all voltages and currents are in good agreement with actual experimental waveforms. The error in drain current rise has been reduced from 40% to 15% (Fig. 3, on right).

The new model enables high-precision simulation of the drain current flowing through the power conversion circuit over the entire rated current range. Circuit designers can spend less time complementing data with experiments, raising work efficiency from the early stages of power converter development. The new model also achieves high-precision simulation of the current waveform (gate current waveform) driving the SiC-MOSFET, unlike in the past (Fig. 3, on left), making it possible to reduce costs by selecting optimum devices that assure sufficient current for driving the SiC-MOSFET.

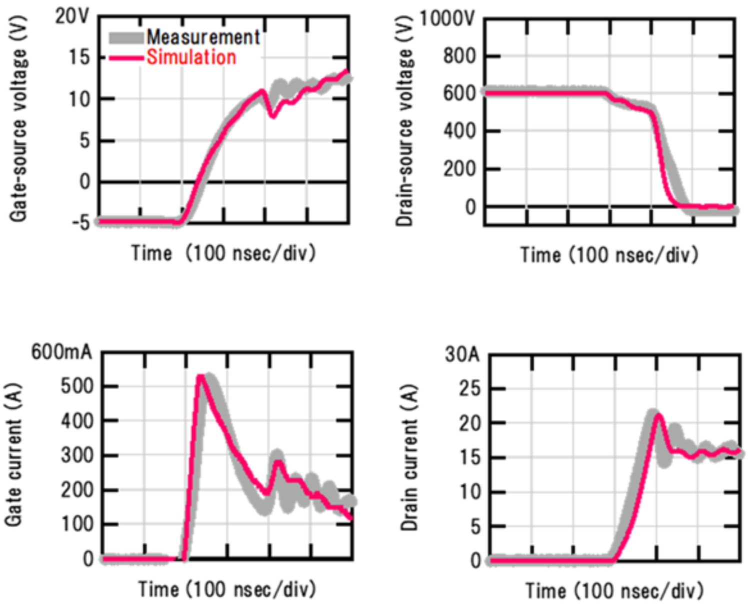

Fig. 3 Example analysis of turn-on switching waveforms

Background

The demand is rising for SiC power semiconductors that significantly reduce power loss. In 2010, Mitsubishi Electric began commercializing SiC power semiconductor modules featuring Schottky barrier diodes (SBDs) and SiC-MOSFETs that are used in inverter systems for air conditioners, industrial equipment, rolling stock and more, helping to reduce power consumption, size and weight. From July, the company will begin providing samples of its latest discrete power semiconductor, the N-series 1200V SiC-MOSFET.

When developing power converters using discrete devices, the designs of power conversion circuits and drive circuits of power semiconductors must be confirmed with simulations. Using the conventional SPICE model, however, the accuracy of current waveform analysis is low, making it necessary to obtain experimental data on a variety of operating conditions to complement the accuracy of SPICE model analysis.

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About Mitsubishi Electric Corporation

With nearly 100 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. Mitsubishi Electric enriches society with technology in the spirit of its corporate statement, “Changes for the Better,” and environmental statement, “Eco Changes.” The company recorded a revenue of 4,462.5 billion yen (U.S.$ 40.9 billion*) in the fiscal year ended March 31, 2020. For more information, please visit www.MitsubishiElectric.com

*U.S. dollar amounts are translated from yen at the rate of ¥109=U.S.$1, the approximate rate on the Tokyo Foreign Exchange Market on March 31, 2020