

News Release

FOR IMMEDIATE RELEASE

Highly durable silicon carbide (SiC) power semiconductor “TED-MOS” for energy saving in electric vehicle motors

Realizing 50% energy conservation and reducing electric field strength by 40%

Tokyo, August 30, 2018 --- Hitachi, Ltd. (TSE: 6501, Hitachi) today announced the development of an original energy saving power semiconductor structure,^{*1} "TED-MOS"^{*2} using next-generation silicon carbide (SiC) material that contributes to saving energy in electric vehicles (EV). This power semiconductor is a new device using a fin-structured trench MOSFET^{*3*4} based on the conventional DMOS-FET^{*5}, a SiC transistor of power semiconductor. Using this new device, an energy saving of 50% was confirmed as the structure reduces the electric field strength, an index of durability, by 40% and resistance by 25% compared to the conventional DMOS-FET. Hitachi intends to apply this device in motor drive inverters^{*6} which are a core component of EVs to increase energy efficiency. Furthermore, by utilizing this technology not only in EVs but also in a range of electrical transducers used in societal infrastructure systems, Hitachi hopes to contribute to efforts to reduce global warming and the realization of a low-carbon society.

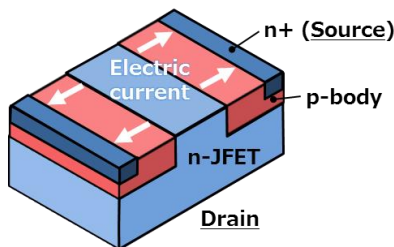
With the anticipated increase in global energy demand, targets to reduce environmental load are being set through initiatives such as the SDGs and COP21 to realize a sustainable society. As the adoption of EVs is also expected to increase dramatically, reducing EV power consumption is considered critical. Thus, the use of power semiconductors using SiC as the semiconductor material which can deliver significant energy savings for inverters, is attracting much attention. One issue, however, is that in SiC power semiconductor, unlike silicon (Si) devices, the resistance varies greatly depending on the crystal plane. Although trench SiC MOSFET (Fig. 1(2)) has been proposed as a means to facilitate the flow of electric current on the crystal plane at a lower resistance in comparison to the conventional DMOS-FET (Fig. 1(1)) structure, as electric fields easily concentrate at the edges of the trench on the base plane, it was difficult to simultaneously achieve high durability.

To address this challenge, Hitachi developed an original fin-structure trench DMOS-FET “TED-MOS” that achieved both a reduction in resistance with the smaller trench pitch and high durability with lower electric fields for industrial applications at high voltage (3.3 kV), and presented these results in May 2018 at the International Symposium on Power Semiconductor Devices and ICs (ISPSD) in Chicago, U.S.A..

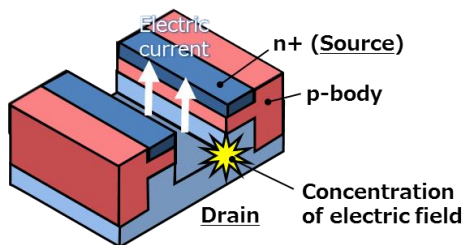
This time, Hitachi has enhanced the “TED-MOS” for EV inverters as they require higher current density at a lower voltage (1.2 kV) (Fig. 1(3)). The “field relaxation layer (FRL)” was developed to reduce the electric field strength extensively, where the PN junction to relax the applied voltage forms in the center of the device structure. In addition, the “current spreading layer (CSL)” was developed to reduce the resistance in the n-JFET region, which serves to form the electric current path connecting the sides of the fin-like trenches as low-resistance crystal planes and the n-JFET region. As a result, “TED-MOS” simultaneously achieves both a smaller electric field strength and lower resistance in SiC power semiconductors.

Image(Figure 1)⁷

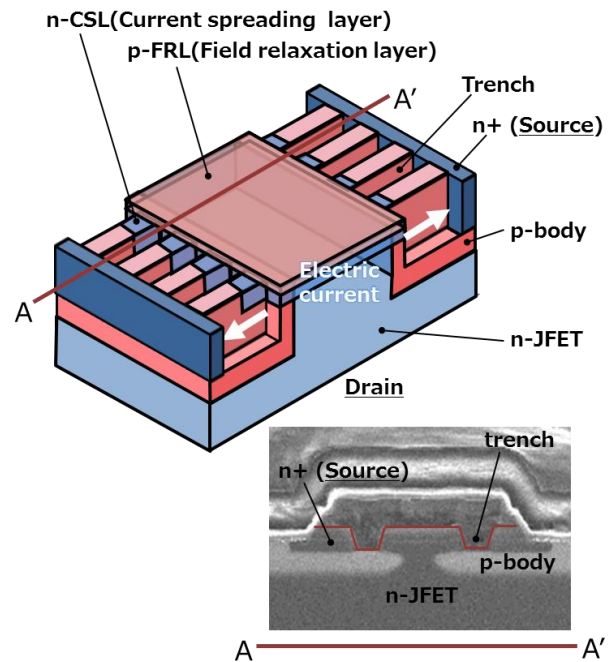
(1) Conventional DMOS-FET



(2) Trench MOSFET already reported



(3) TED-MOS



The benefits of this technology development was verified using a prototype device. It was found that the “TED-MOS” reduced the electric field strength by 40% and resistance by 25% in comparison to the conventional DMOS-FET while maintaining the rated voltage of 1.2kV required for the motor drive in EVs. Furthermore, the modified device structure mentioned above also improved the switching speeds between ON/OFF of the power semiconductor, and as a result, energy loss in the electric current due to this switching operation was also reduced by 50%.

Going forward, Hitachi will contribute to the prevention of global warming and the realization of a low-carbon society by applying this technology to various electrical transducers, not only in EVs but also in various societal infrastructure systems.

The results of this research will be presented at the European Conference on Silicon Carbide and Related Materials (ECSCRM), to be held from 3-6 September 2018, in Birmingham, U.K.

*1 TED-MOS: Trench Etched DMOS-FET

*2 Semiconductor used for converters or inverter in electrical transducers

*3 MOSFET⁴ structure in which electric current flows on the sides of fin-like trenches

*4 MOSFET: Metal-Oxide-Semiconductor Field-Effect-Transistor

*5 DMOS-FET: Double Diffused MOSFET

*6 Inverter: The device which controls motor number of revolutions by changing the power supply frequency of the motor freely

*7 n+ (source): highly impurity doped n-type region (source region), P-body: p-type impurity doped region (body region),
n-JFET: n-type impurity doped Junction-barrier FET, Drain: n-type impurity doped region (drain region).

About Hitachi, Ltd.

Hitachi, Ltd. (TSE: 6501), headquartered in Tokyo, Japan, delivers innovations that answer society's challenges, combining its operational technology, information technology, and products/systems. The company's consolidated revenues for fiscal 2017 (ended March 31, 2018) totaled 9,368.6 billion yen (\$88.4 billion). The Hitachi Group is an innovation partner for the IoT era, and it has approximately 307,000 employees worldwide. Through collaborative creation with customers, Hitachi is deploying Social Innovation Business using digital technologies in a broad range of sectors, including Power/Energy, Industry/Distribution/Water, Urban Development, and Finance/Social Infrastructure/Healthcare. For more information on Hitachi, please visit the company's website at <http://www.hitachi.com>.

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