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§8. Fundamental Study on Cryogenic Characteristics of SiC Power Device and Its Application to AC/DC Converter

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Fundamental Study on Improvement and Stabilization of Electric Power Quality by Flywheel Energy Storage System

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For application to flywheel energy storage system or magnetic field coil system of nuclear fusion experimental machine, its power supply has been constructed with the power electronics device as switching element of AC/DC converter, for example IGBT, GTO etc. As the large capacity power supply is required for such application in future, high efficiency and low operational loss of power supply are important issues. Especially, for high current operation of large capacity power supply, more efficient power electronics device than conventional one should be used. Recently, some advanced power electronics devices have been developed, which are based on crystallized SiC material or super junction type modified one based on crystallized Si material.

In our previous study, the Schottky Barrier Diode (SBD) based on crystallized SiC material was investigated in comparison with conventional Si-based SBD. In this study, the super junction type power-MOSFET is investigated, which is one of unipolar power electronics devices and an advanced device based on crystallized Si material. Power-MOSFET is well known device to be applied to high efficient power supply, not so large capacity one. To use power-MOSFET for large capacity power supply, it is required that its on-state resistance is lowered with high withstand voltage specification.

The super junction type power-MOSFET is one of advanced power electronics devices to achieve lower on-state resistance value in higher voltage region. The static voltage-current characteristics and the on-resistance value are investigated with SPA20N60C3 (650V, 20.7A) and the temperature dependence of the voltage-current characteristics is clarified. Considering to cool down the power electronics device for high current operation, the static voltage-current characteristics are measured in room and liquid nitrogen temperature. Main results are summarized as follows.

(i) The on-state resistance value in room temperature is about 0.16 ohm. (See Fig. 1)
(ii) The on-state resistance value in liquid nitrogen temperature is about 0.035 ohm, which is 20 % of that in room temperature approximately. (See Fig. 2)
(iii) The built-in voltage of body diode of power-MOSFET is about 0.7 (V) in room temperature and about 1.0 (V) in liquid nitrogen temperature respectively.

As the measured result of voltage-current characteristics of super junction type power-MOSFET, the reduced on-state resistance in liquid nitrogen temperature can promise to conduct high current without increasing the operational loss of AC/DC converter. Furthermore, SiC-based power-MOSFET would be expected to show the same trend of static voltage-current characteristics as that of Si-based power-MOSFET and to contribute to high efficiency operation of large capacity power supply.

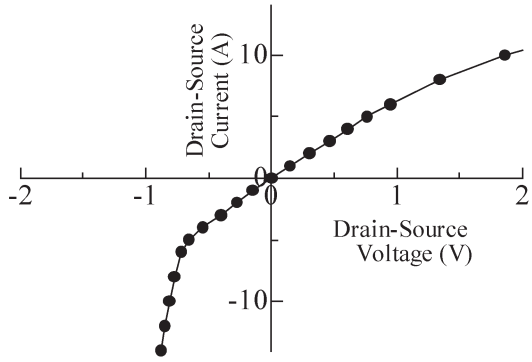

Fig. 1. The static voltage-current characteristics of super junction type power-MOSFET(SPA20N60C3) in room temperature

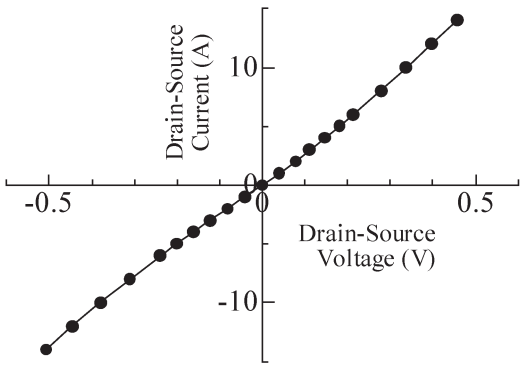

Fig. 2. The static voltage-current characteristics of super junction type power-MOSFET(SPA20N60C3) in liquid nitrogen temperature