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Modification of Electrical and Switching Characteristics of a Non Punch-Through Insulated Gate Bipolar Transistor by Gamma Irradiation

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Abstract : Fast neutron irradiation using nuclear reactors is an effective method to improve switching loss and short circuit durability of power semiconductor (insulated gate bipolar transistors (IGBT) and insulated gate transistors (IGT), etc.). However, not only fast neutrons but also thermal neutrons, epithermal neutrons and gamma exist in the nuclear reactor. And the electrical properties of the IGBT may be deteriorated by the irradiation of gamma. Gamma irradiation damages are known to be caused by Total Ionizing Dose (TID) effect and Single Event Effect (SEE), Displacement Damage. Especially, the TID effect deteriorated the electrical properties such as leakage current and threshold voltage of a power semiconductor. This work can confirm the effect of the gamma irradiation on the electrical properties of 600 V NPT-IGBT. Irradiation of gamma forms lattice defects in the gate oxide and Si-SiO₂ interface of the IGBT. It was confirmed that this lattice defect acts on the center of the trap and affects the threshold voltage, thereby negatively shifted the threshold voltage according to TID. In addition to the change in the carrier mobility, the conductivity modulation decreases in the n-drift region, indicating a negative influence that the forward voltage drop decreases. The turn-off delay time of the device before irradiation was 212 ns. Those of 2.5, 10, 30, 70 and 100 kRad(Si) were 225, 258, 311, 328, and 350 ns, respectively. The gamma irradiation increased the turn-off delay time of the IGBT by approximately 65%, and the switching characteristics deteriorated.

Keywords : NPT-IGBT, gamma irradiation, switching, turn-off delay time, recombination, trap center
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