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Enhanced Effects of Neutron Displacement Damage on Total Ionizing Dose Degradation in SOI MOSFET and Gate-controlled Lateral PNP Bipolar Transistor

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SOI MOSFET and Gate-controlled Lateral PNP Bipolar Transistor (GCLPNP) are two kinds of semiconductor devices sensitive to total ionizing dose effects (TID). Generally it is thought that TID and displacement damage are independent with each other, however, recent research indicates that total ionizing dose degradations in these two kinds of devices can be enhanced by high fluence neutron induced-displacement damage. In order to investigate the physical mechanisms, TCAD simulations and TCAD-SPICE mixed simulations were carried out to simulate the collector current Ic versus gate voltage Vg (sub-threshold sweep characteristics) and gate-substrate capacitance Cgs versus gate voltage Vg (C-V characteristics) of GCLPNP, and drain-source current Ids versus gate voltage Vg (transfer characteristics) of SOI MOSFET. The displacement damage induced by neutron irradiation was simulated by inserting hole traps in the oxide layer, and its influence on TID degradation was simulated by modelling the capture process of carriers ionized by gamma irradiation in the displacement-induced hole traps. The results indicate that neutron-induced displacement damage in the oxide layer can increase the sensitivity of subsequent total ionizing dose degradation, leading to enhanced voltage shift of sub-threshold sweep characteristics and C-V characteristics of GCLPNP and transfer characteristics of SOI MOSFET. Besides, the displacement damage in the buried oxide layer can also lead to more severe subthreshold leakage current in SOI MOSFET. The results are beneficial to radiation hardening design in mixed irradiation environment of neutrons and gamma rays.

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