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The Effects of Gamma Irradiation on Neutron Sensitivity of Lateral PNP Bipolar Transistors: Investigations and Simulations

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Lateral PNP bipolar transistors with different neutral base widths, base doping concentrations and emitter perimeters have been first irradiated with gamma rays then neutrons and compared to the same devices exposed to neutrons only. The data shows that gamma irradiation can make subsequent neutron displacement damage larger and this phenomenon may be due to the increased surface potential induced by the accumulated positive charge in the oxide layer above base region during gamma irradiation. In order to verify this analysis, further neutron radiation effect experiments have been accomplished on the gate-controlled lateral PNP bipolar transistors manufactured in the identical commercial bipolar process whose bias voltage of the gate is zero and 10V respectively. The data reveals that the increased surface potential simulated by the positive bias condition enhances the neutron degradation rate consistent with previous analysis. With semiconductor device simulation software TCAD, numerical simulations of the effects of gamma irradiation on neutron sensitivity have been carried out to find out the physical mechanisms by means of adding positive charge to the oxide layer above base region and changing the minority carrier lifetimes in the bulk of the transistors. The results indicate that the increased surface potential caused by first gamma irradiation affects the transportation process of electrons and holes near Si/SiO2 interface and in the bulk, leading to more rapid gain degradation of the transistors compared to those irradiated with neutrons only. These effects have important radiation tolerance implications.

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