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Total Ionization Damage Compensations in Double Silicon-on-Insulator Pixel Sensors

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We are developing monolithic pixel sensors based on a 0.2 um fully-depleted Silicon-on-Insulator (SOI) technology. Such sensors have properties such as high-speed operation, low-power dissipation, and SEU/SET immunity. The major issue in applications them in high-radiation environments is the total ionization damage (TID) effects. The effects are rather substantial in the SOI devices since the transistors are enclosed in the oxide layers where generated holes are trapped and affect the operation of the near-by transistors.
The double SOI sensors that provide an independent electrode underneath the buried oxide (BOX) layer have been developed. A negative voltage applied to this electrode is expected to cancel positive potential due to hole traps in the BOX layer.
We have irradiated transistor test elements and pixel sensors with γ-rays. By adjusting the potential of this electrode, the TID effects are shown to be compensated. The transistors irradiated to 2 MGy recovered their performances by applying a bias to the electrode. Transistors were shown to have modest differences in behaviors of TID compensations according to their types. Furthermore, differences depending on the biasing condition during irradiation were observed. The pixel sensor irradiated to 100 kGy recovered its functionality by applying a bias to the electrode. We used infrared laser pulse and γ-ray sources to evaluate TID compensations of pixel sensors. The radiation tolerance of the SOI devices has been substantially improved by employing the innovative double SOI.

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