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Proton Radiation Damage Experiment for X-ray SOI Pixel Detectors

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X-ray Charge Coupled Devices (CCDs) are commonly used in modern X-ray astronomical satellites. Although the CCDs have good energy resolution, they have poor time resolution (a few seconds). Therefore we have been developing XRPIX which is a monolithic active pixel sensor based on Silicon On Insulator (SOI) CMOS technology for future satellites. XRPIX has time resolution shorter than 10 μs. Furthermore, XRPIX has similar energy resolution to the CCDs because of small parasitic capacitance owing to SOI technology.
In low earth orbit, there are many cosmic rays which are composed primarily of high energy protons. By interacting with the cosmic rays, semiconductor detectors are damaged, and their performance such as energy resolution gets worse. Thus, to examine their radiation hardness is one of important issues.
We used heavy ion accelerator at National Institute of Radiological Science in Chiba to perform our proton radiation damage experiment for XRPIX. We irradiate 6 MeV proton to XRPIX2b-FZ. With 410 rad irradiation, whose equivalent time in orbit is 3.5 years, degradations of gain and energy resolution are less than 0.4% and 10%, respectively.
After more proton irradiation, specifically at 6000 rad, gain increases by 1% and energy resolution gets worse by 10% than those with no damage. In addition, a fraction of bad pixels, whose read out noise is worse than 3σ of the average noise of all pixels, increases from 0.4% at 0 rad to 2.5% at 6000 rad.

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