Reliability study for bulk and SOI SRAMs using high energy nuclear probes

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A single event upset (SEU) in semiconductor devices due to high energy particles, which results from a cosmic ray, was firstly reported by J. F. Ziegler in 1970s [1]. Recently, this problem becomes more serious for advanced devices with a feature size of less than 0.35 μm. A silicon-on-insulator (SOI) device has advantages over conventional bulk devices for the SEU. However, the SOI device has its inherent problem, i.e., a floating body effect. In the SOI device, the channel region is insulated from the silicon substrate by the buried oxide (BOX). The excess carriers generated by impact ionization are accumulated at a neutral region of the partially depleted SOI body. These accumulated excess carriers increase the SOI body potential and cause another SEU in the SOI device.

In this study, the difference of the errors in the bulk and SOI SRAMs was investigated by 300 – 800 keV proton microprobe irradiation for a dose rate at 19.2 protons / μm^2 sec with 10 sec. The position and thickness of the excess carrier generation in bulk and SOI SRAMs were freely controlled by changing the incident energy and position of proton microprobes. In the bulk SRAM, the hard errors by latch up were occurred in the control circuits. On the contrary, in the SOI SRAM, only soft errors by floating body effect were occurred in the memory cells and the soft error rate (SER) depended on the irradiation energy of proton microprobe.

[1] J. F. Ziegler et al., IBM Journal of Research and Development, 40, Number 1, 1996, pp. 3-18.