Soft Errors of SRAM Induced by Alpha Particles and Neutrons

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Soft errors of memory devices are becoming serious problem with downsizing of LSI. High energy neutrons and thermal neutrons in terrestrial cosmic ray, and alpha particles from radioactive decay of U, Th in mold resin were considered to be the three major causes of LSI soft errors [1, 2]. We found that the thermal neutron induced soft error can be reduced to negligible level [3], so our current concern is about alpha particles and high energy neutrons. In order to measure only alpha-induced soft error rate (SER), underground test where cosmic rays are effectively shielded is very effective. We have performed underground tests at Oto Cosmo Observatory for more than two years. Intense neutron beam which has similar energy spectrum as terrestrial cosmic neutron is useful to obtain high energy neutron induced SER. A spallation neutron beam line is under construction at RCNP for this purpose. In this report, we describe the summary of the underground experiment and the preliminary results on the spallation neutron beam line.

Underground experiment

The phase I experiment for 0.18um SRAM devices was performed from February 2001 to March 2003. The results are summarized in Table I. Up to this day, the polyimide layer was usually inserted to absorb alpha particles, and alpha particle induced SER was negligible thanks to the polyimide layer. However, the polyimide layer is not used to the future devices for technical reasons; we tested SRAM devices without the polyimide layer. Four soft errors were observed in 9573 hours. It is comparable to the high energy neutron induced SER. Therefore, we are going to start the phase II experiment for 0.13um SRAM in July. The purpose of the experiment is to obtain alpha induced SER of the new devices and to verify the appropriateness of the accelerated tests using ^{241}Am.

Table I Summary of the phase I underground experiment at Oto Cosmo Observatory

Device	0.18um 8M SRAM
Polyimide layer	None
# of devices	527
Period	2/28/2001 – 3/27/2003
Elapsed time	9573 hour
# of soft errors	4

Spallation neutron beam line

The spallation neutron beam line at Los Alamos Neutron Science Center (LANSCE) produces a neutron beam with the similar energy spectrum as terrestrial cosmic neutrons and with the intensity of approximately 100,000,000 times. A similar neutron beam line is under construction at RCNP. The preliminary results of the neutron energy spectrum and the intensity using various thicknesses of Pb targets are shown in Fig.1. A similar neutron energy spectrum was obtained using a 10cm-thick Pb target.

The maximum neutron energy is determined by the incident proton energy, 400 MeV for RCNP and 800 MeV for LANSCE. Since SER induced by neutrons with energy grater than 400 MeV is very small because of the low flux in this energy region, the difference of maximum neutron energy is not serious issue.

Neutron intensity per proton beam current is approximately 0.1 of that of LANSCE. The maximum proton beam current is 1uA at RCNP and 5uA at LANSCE, however, the geometrical acceptance at RCNP is 4-5 times larger than LANSCE, so the difference of incident proton beam current can be compensated. Totally, neutron flux at RCNP is expected to be approximately 0.1 of LANSCE. The construction of the spallation neutron beam line is scheduled to be finished in July, then test experiments will start.

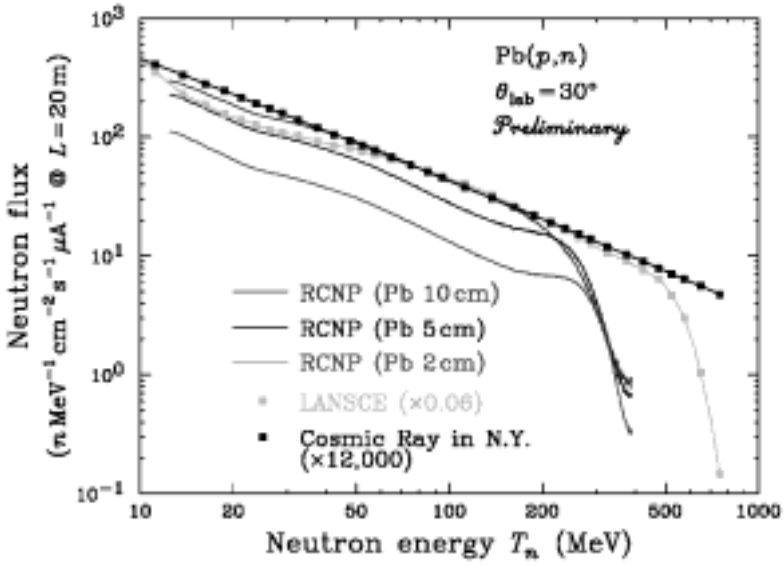

Fig.1 Comparison of neutron energy spectra at RCNP and LANSCE

References

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