Comparison of acceleration soft-error tests using white neutron beam and quasi-monoenergetic neutron beam

S. Yamamoto,[a] K. Kokuryou,[b] H. Sugimoto,[c] J. Mitsuhashi,[a] N. Matsuoka, [d] and Y. Nagai[d]
[a] *Renesas Technology Corporation, Mizuhara,Itami,Hyogo 664-8641, Japan*
[b]*Tada electric Corporation, Higashitada,Kawanishi,Hyogo 666-0122, Japan*
[c] *Renesas Semiconductor Engineering Corporation., Mizuhara,Itami,Hyogo 664-8641, Japan*
[d]*Research Center for Nuclear Physics (RCNP), Ibaraki,Osaka 567-0047, Japan*

Neutron-induced soft error is a serious reliability issue for semiconductor devices [1-2]. It is therefore important to accurately predict neutron-induced soft-error rate (SER). There are two acceleration test methods for the estimation of neutron-induced soft-error rate [3]: an irradiation test using a white neutron beam, and an irradiation test using a quasi-monoenergetic neutron beam. We investigated the difference between both test methods using white and quasi-monoenergetic neutron beams at the Research Center for Nuclear Physics of Osaka University.

We used 0.15ìm SRAM in the acceleration test. The test boards mounted with 0.15ìm SRAM were set up along the beam line. Before beam irradiation, an all-zero data pattern was written from the external controller. Failed addresses were stored in the external controller after beam irradiation. For the quasi-monoenergetic neutron beam, the energies used were 14, 26, 62, 98, 148, 198 and 392MeV and neutrons were produced by a ^{7}Li(p,n)^{7}Be reaction. Figure 1 shows the quasi-monoenergetic neutron beam energy spectrums obtained using a liquid scintillator. Each neutron energy spectrum has a high-energy peak and a low-energy tail. Low-energy-tail correction is essential for the accurate estimation of SER cross section in the quasi-monoenergetic neutron beam test. We performed the low-energy-tail correction using the iterative folding procedure described in ref.4. Figure 2 shows the nominal energy distribution at sea level [3] and the white-neutron-beam energy distribution of RCNP using the nuclear reaction between a Pb target and a 392MeV proton. The energy distribution of RCNP is very similar to the nominal energy distribution, but has a higher intensity.

Figure 3 shows SEU cross sections as a function of neutron energy En in 0.15ìm SPRAM. SEU cross section rises rapidly and almost saturates at more than 60MeV. In the quasi-monoenergetic neutron beam irradiation test, SER was calculated using

$$\mathrm{SER} = \int \sigma c(\mathrm{En}) \cdot F(\mathrm{En}) dE, \qquad (1)$$

where $\sigma c(\mathrm{En})$ is the SEU cross section corrected for the contribution obtained from neutrons in the low-energy neutron tail and F(En) is the differential neutron flux, which is as a function of En.

In the white-neutron beam irradiation test, we calculated the SER of 0.15ìm SPRAM on basis of JEDEC STD [3]. Figure 4 shows the estimated SERs obtained in both acceleration tests. The SER of the white neutron beam is in good agreement with that of the quasi-monoenergetic neutron beam.

We performed two SER acceleration tests with a quasi-monoenergetic neutron beam and a white neutron beam using 0.15ìm SPRAM. SER can be predicted accurately using the white neutron beam, as in the case using the quasi-monoenergetic neutron beam.

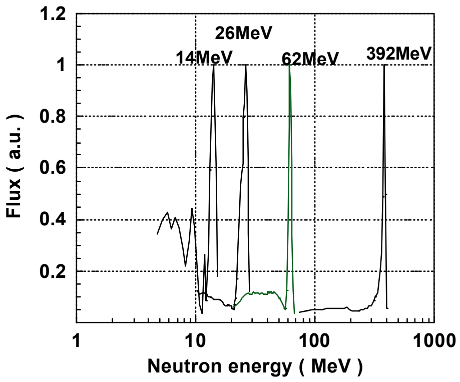

Figure 1. The quasi-monoenergetic neutron beam energy spectrums

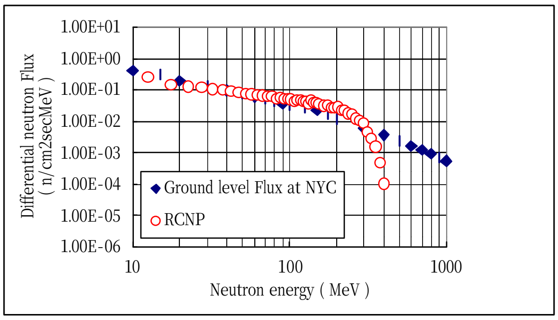

Figure 2. The white neutron beam energy distribution

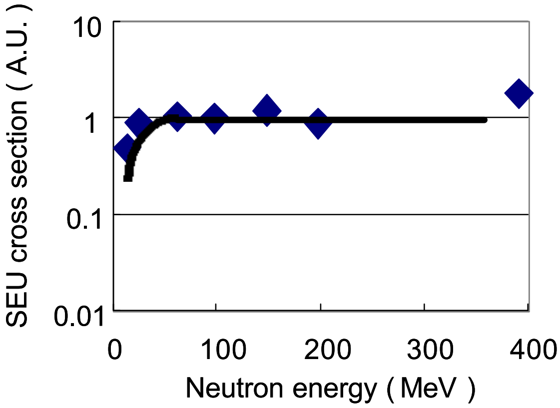

Figure 3. The neutron energy dependence of SEU cross section of 0.15um SRAM

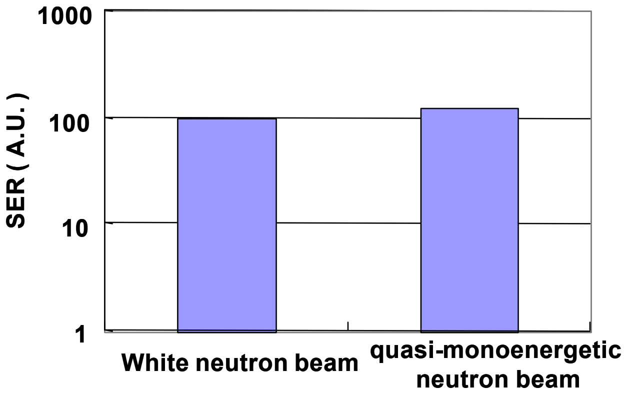

Figure 4.comparison of SER from white and quasi-monoenergetic neutron beam

References

[1] W.R. McKee *et al*, "Cosmic Ray Neutron Induced Upsets as a Major Contributor to the Soft Error Rate of Current and Future Generation DRAMs", *IRPS Proceedings*., pp.1-6,1996.

[2] J. F. Ziegler, "IBM Experiments in Soft Fails in Computer Electronics (1978-1994)", *IBM J. Res. Develop*., vol. 40, p.3,1996.

[3] JESD 89,JEDEC.

[4] K. Johansson *et al*, "Energy-Resolved Neutron SEU Measurements from 22 to 160MeV", *IEEE Transactions on Nuclear Science*, Vol.45, pp. 2519-2526,1998.