Soft-error measurement of SRAM using quasi-monoenergetic neutron beam

S. Yamamoto,[a] K. Kokuryou,[b] O. Ihokura,[c] Y. Okada,[a] J. Mitsuhashi,[a] N. Matsuoka, [d] A. Tomyo, [d] H. Makii, [d] M. Segawa [d] and Y. Nagai[d]

[a] Renesas Technology Corporation, Mizuhara,Itami,Hyogo 664-8641, Japan

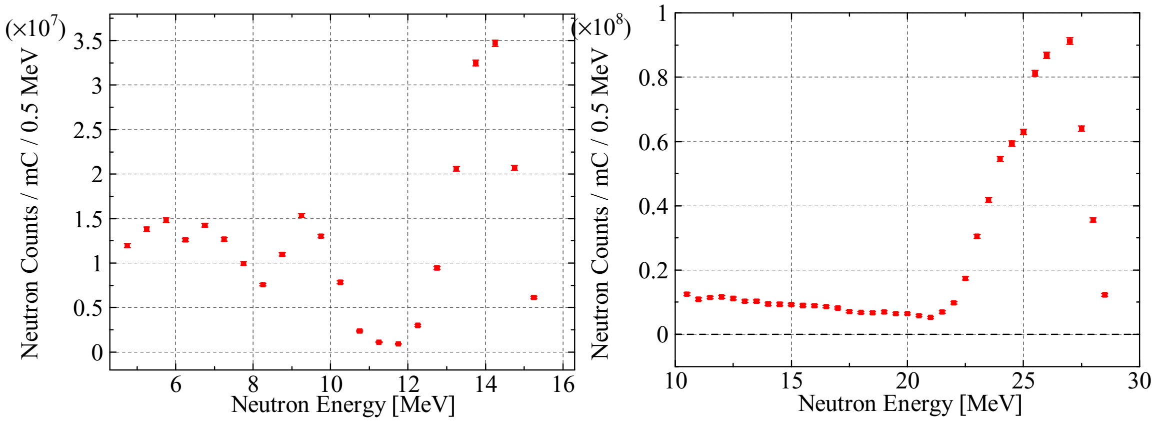
[b]Tada electric Corporation, Higashitada,Kawanishi,Hyogo 666-0122, Japan

[c]Daioh electric Corporation, Ogino,Itami,Hyogo 664-0002, Japan

[d]Research Center for Nuclear Physics (RCNP), Ibaraki,Osaka 567-0047, Japan

It is well known that neutron-induced soft error is a serious reliability issue for semiconductor devices [1-3]. Therefore it is important to predict neutron-induced soft-error rate (SER) accurately. Generally, there are two acceleration test methods for the estimation of neutron-induced soft-error rate [4]. One is an irradiation test using Weapons Neutron Research (WNR) beam at LANL. The other is an irradiation test using a quasi-monoenergetic neutron beam. We investigated the single-event-upset (SEU) cross section of 0.18um SRAM device by the irradiation test method using 14-200MeV quasi-monoenergetic neutron beams at the Research Center for Nuclear Physics of Osaka University.

The energies of the neutron beam were 14,26,62,98,148 and 198MeV. Neutrons were produced by the $^{7}Li(p,n)^{7}Be$ reaction. Figure 1 shows the 14MeV and 26MeV neutron beam energy spectrums obtained using a liquid scintillator. Each neutron energy spectrum has a high energy peak at around 14MeV or 26MeV and a low energy tail [5]. The neutron flux density at the peak ranges from 1×10^{3} to 1×10^{4} n/cm^{2}/sec. The 14MeV neutron flux density is approximately 1/10 of the flux density of high-energy neutrons (62-198MeV).



(a) 14MeV

(b) 26MeV

Figure 1. The energy spectrums of 14MeV and 26MeV neutron beam.

The test boards mounted with two SRAMs were set up along the beam line. Before beam irradiation, the all-zero data pattern was written from the external controller. The failed address was stored in the external controller after beam irradiation. The energy dependence of the SEU cross section of the 0.18um SRAM is shown in Fig. 2. The SEU cross section is nearly constant in the energy range from 62MeV to 200MeV and rapidly decreases to 1/10 with decreasing neutron energy to 14MeV. A neutron-induced SER is calculated by the integration of the (SEU cross section)*(neutron flux). It is well known that the neutron flux is large when the ground level neutron energy is low. Therefore, the low-energy dependence of the SEU cross section has an impact on SER prediction directly.

We performed a SER acceleration test using quasi-monoenergetic neutron beams with 14-200MeV. The SER of the 0.18um SRAM can be predicted by SEU cross section at the low-energy region (<62MeV) accurately.

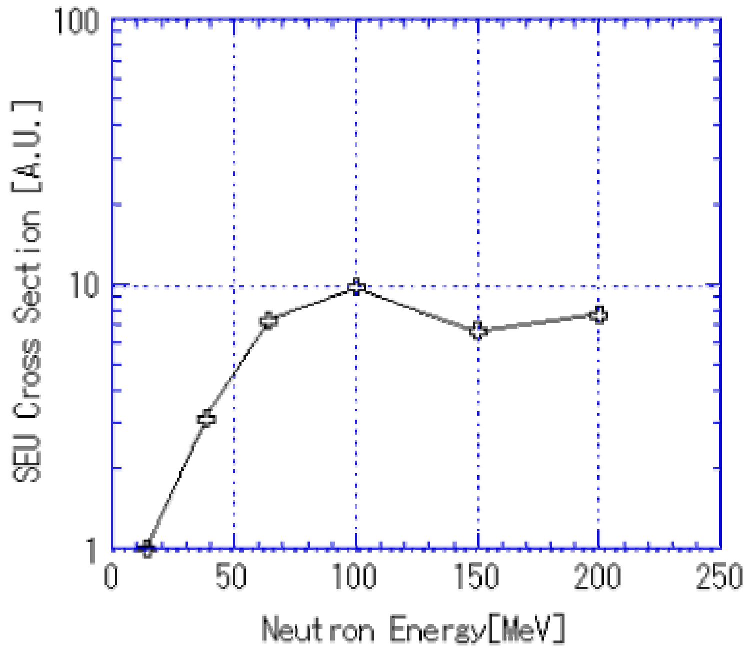


Figure 2. The neutron energy dependence of SEU cross section

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] T.J. O'Gorman *et al*, "Field Testing for Cosmic Ray Soft Errors in Semiconductor Memories", *IBM J. Res. Develop*., vol. 40, p.41,1996.

[4] JESD 89,JEDEC.

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