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Development of a Measurement Method of Neutron Energy-Dependent SEU Cross-Section Less than 0.1 MeV Using the 1/v Law

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In recent years, the increase in the soft error rate (SER) caused by cosmic ray-neutrons on the ground has become a serious problem due to the miniaturization, high integration, and low power consumption of semiconductor devices. Therefore, it is important to design semiconductor devices considering SER. Estimation of SER for various environments requires the information of the neutron energy-dependent soft error probability (SEU cross-section) of each semiconductor device. We have successfully measured such SEU cross-section data from 10 meV to 800 MeV by the time-of-flight (TOF) method at high intensity short-pulsed neutron source facilities. As the result of these measurements, it was found that SEU cross-sections follow the 1/v law less than 0.1 MeV [1]. Based on this finding, in this study, we developed a measurement method utilizing the 1/v law for deducing the energy-dependent SEU cross-sections less than 0.1 MeV which can be conducted at a compact accelerator-driven (steady-state) neutron source.

First, we measured the SERs of some semiconductor devices induced by thermal neutrons (Data A) and the thermal neutron flux by the gold foil activation method at an 18 MeV proton cyclotron-driven neutron source of SHI-ATEX Co., Ltd. Next, we calculated irradiated thermal neutron energy spectrum (Data B) by Monte-Carlo particle transport simulation calculation code, PHITS, and converted this to the absolute value based on the measured thermal neutron flux. Finally, we derived the 1/v-dependent SEU cross-sections less than 0.1 MeV based on the results of Data A and Data B. Then we compared it with the results obtained by the TOF method. The results showed good agreement in the energy range from 10 meV to 0.1 MeV with an average difference of 3%.

References

[1] H. Iwashita, R. Kiuchi, Y. Hiroshima, Y. Okugawa, T. Sebe, M. Takeda, H. Sato, T. Kamiyama, M. Furusaka and Y. Kiyanagi, IEEE Transactions on Nuclear Science, 70, 216-221 (2023).

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