# Investigation of Nuclear Reaction Data for Analyses of Single-event Effects in Semiconductor Devices

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In recent years, nucleon-induced single-event upsets (SEUs) have always been a serious concern for microelectronic devices employed in various radiation environments. For instance, terrestrial cosmic-ray neutrons hitting the earth have the wide energy range from MeV to GeV, and are regarded as one of major sources of the SEUs in the devices used on the ground or in airplanes. And, protons are very important for the SEUs in the devices used in the space environment.

In a microscopic scale, the nucleon-induced SEU process starts from the interaction of an incident cosmic-ray particle with materials in a device. Then, light charged particles and heavy recoils are generated via the nuclear reaction with atomic nucleus. They give rise to local charge burst in a sub micron-size volume while passing through the device, which result in upsets of the memory cell information quantum. Therefore, one needs nuclear reaction data that provides us with the probability of the initial interaction of neutrons with device materials, when estimating the SEU rate by numerical simulations.

We have developed a cross section database of $^{28}$Si for incident neutron energies ranging from 2MeV to 3GeV, on the basis of evaluated nuclear data files and nuclear model calculations. The database has been applied to simulation of the initial processes in the SEU phenomena, *i.e.,* the nucleon-induced nuclear reaction and the sequential charge deposit by secondary ions, using a simplified device model. [1)] In this study, we have investigated three effects (simultaneous multi-ions emission, energy spectral shape of secondary ions, and elastic scattering) which are expected to be important for initial processes in nucleon-induced SEU phenomena. In addition, we discuss a method of estimating nucleon-induced SEU cross-section empirically from experimental heavy-ion SEU data on the basis of the simulation of the initial processes.

Reference

1) Y. Watanabe., et al., Proc. of International Conference on Nuclear Data for Science and Technology (ND2004), SantaFe, USA, Sep. 26 – Oct. 1, 2004, AIP Conference proceedings, vol. **769** (2005), pp. 1646 – 1649.