Measurement of Fragment Production Cross-section on Nucleon-induced Reaction.

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Fragments (secondary charged particles heavier than Li-particle) produced for proton- and neutron-induced reactions are considered as the main cause in radiation effect of semiconductor devices such as single event upset (SEU) because of their large local ionization. To evaluate the effect, the energy and angular doubly-differential cross-section data of the fragment production are required. However, experimental data on the fragment production are very scarce due to experimental difficulties of fragment detection, i.e., low yield and large energy loss. Most of past experimental data were obtained by the activation method that does not provide energy and angle information. Furthermore, theoretical calculation treating fragment production is few and uncertain. Therefore, it is important to obtain reliable experimental data of differential cross-section for fragment production.

For the fragment detection, we adopted 1) a Bragg curve spectrometer (BCS) providing almost all information on the particle with a single counter in large solid angle and 2) an energy-time-of-fight (E-TOF) method having the capability of mass identification even in the energy region where BCS is not applicable, while the solid angle is very small.

BCS has been used mainly for fragment measurement in heavy charged-particle induced reactions but not applied to neutron-induced reactions. We designed BCS with special care to apply to a neutron beam in addition to a charged particle beam, and resulted in success to identify the fragments by proton- and neutron-induced reactions. BCS proved very promising for fragments detection even in neutron-induced reaction, while there are still some problems that should be solved. An E-TOF method is restricted only to charged particle-induced reactions due to small detector solid angle. The dynamic range of fragment energy will be higher than in BCS.

In this paper, we introduce our activities of fragment measurements by BCS and E-TOF method together with the activities by other facilities.