Measurement of double differential fragment production cross sections of silicon for 70 MeV protons.

M. Hagiwara*, T. Oishi, S. Kamada, T. Okuji, M. Baba
Cyclotron and Radioisotope Center, Tohoku University, Sendai, Japan

T. Sanami
High Energy Accelerator Research Organization (KEK), Tsukuba, Japan

M. Takada, N. Miyahara
National Institute of Radiological Sciences (NIRS), Chiba, Japan

Abstract

Secondary charged particles for neutron-induced reactions are the principle cause of radiation dose and radiation effects of medium to high energy neutrons. Thus far, however, only light charged particles with high production rate have been taken into account for the estimation of the effects. Secondary charged particles heavier than lithium which are called fragment have recently been recognized to be of importance particularly in the fields of the space technology and accelerator applications because they have significant effects even with a single hit due to a large LET (linear energy transfer) in spite of the lesser production rate. A large fraction of radiation effects to semiconductor devices such as single-event upset and latch up on the ground level are thought to be triggered by neutron-induced fragments. However there are no systematic experimental data for neutron-induced fragment production in particular for the energy angular double-differential cross-section (DDX). Even for proton-induced reactions, experimental DDX data are too few to do quantitative assessment of the effects.

We have developed a Bragg curve spectrometer (BCS) suitable to DDX measurements for fragment emission reactions induced by neutrons as well as protons, and obtained the experimental data in ten's of MeV region. The BCS has advantages of a large detector solid angle, large dynamic ranges and good signal-to-background ratio compared with the past similar counters.

To measure systematic DDX data of fragment production for silicon, we used a silicon film (310μg/cm^2) vaporized on a tantalum foil (10μm) as a silicon sample, and measured background events using a pure tantalum foil (10μm). The measurements were performed at the AVF cyclotron facility in NIRS. Fragments from He to O emitted to 30 deg – 135 deg were measured systematically. An energy-time-of-flight (E-TOF) method was also employed at 30 deg. measurement to complement the BCS data.

Experimental DDX data of fragment production obtained by the BCS and E-TOF method are compared with the evaluated data and theoretical calculations such as LA-150, TALYS, INC model (Bertini and Isobar model), QMD model, respectively. The comparisons show systematic deviation of calculations from the experimental data.