§18. Recycling of Fuel Particles and Production and Transport of Impurities at the First Wall

Morita, K., Soda, K., Yuhara, J. (Dept. Cryst. Mater. Sci., Nagoya Univ.), Tanabe, T., Muto, S., Yoshida, T. (CIRSE, Nagoya Univ.), Ohya, K. (Tokushima Univ.), Oogo, T. (Fukuoka Univ. of Education), Muroga, T., Masuzaki, S., Inoue, T., Noda, N., Motojima, O.

For detailed understanding of the particle balance as well as the energy balance in the recycling of fuel and ash particles at the plasma facing materials of fusion devices, it is of essential importance to measure directly the energy spectra of the neutral particles emitted through the boundary plasma via the charge exchange processes in dependence on time. One of the most promising techniques for measuring the energy of neutral particles is the time of flight (TOF) analysis. Recently, a microchannel plate used in a commercial coaxial impact collision ion scattering spectroscopy (CAICISS) system has been eventually found to have a significant quantum efficiency in detection of low energy neutral particles. In order to use the microchannel plate for neutral particle detection in the region of a few hundreds eV. it is primarily necessary to determine the absolute value of the quantum efficiency in dependence on the particle energy.

In this report, we describe the experimental data on the quantum efficiencies of the microchannel plate for detection of sub-keV D and He particles in dependence on the kinetic energy which have been estimated from comparison of the Sb peak intensities of them reflected from the Si(111)-$\sqrt{3}\times\sqrt{3}$ Sb surface with the theoretical ones calculated using the elastic scattering cross-section assumed [1].

The Si(111)-$\sqrt{3}\times\sqrt{3}$Sb surface used was prepared by deposition of Sb films of about one monolayer (7.8×10^{14} atoms cm^{-2}) in thickness onto the Si(111)-7×7 -surface and subsequent heating for 10 min at 300℃. The Sb thickness measured by RBS was 0.90 ML, thus suggesting that there were no Sb islands on the Si(111)-$\sqrt{3}\times\sqrt{3}$Sb surface.

The time of flight measurements of neutral particles reflected at an angle of ~ 180° from the sample, irradiated with He^+ ions or D_2^+ ions at different incident energies of 2.0, 1.5, 1.0, 0.75 and 0.50 keV, were carried out using the CAICISS system constructed newly under the LHD Joint Planning Research, in which the sample surface was placed at 95cm and 120cm far away from the microchannel plante and the exit edge of chopping electrodes, respectively and the width and the repetition cycle of the pulsed incident ion beam were 150 n sec and 50 k Hz, respectively.

Typical TOF spectra of neutral particles scattered from the Si(111)-$\sqrt{3}\times\sqrt{3}$ Sb surface irradiated with He^+ and D_2^+ ion beams were found to consist of a sharp peak scattered from the Sb adsorbates and a broad peak tailing to the low energy from the Si crystalline substrate. The peak intensities from the Sb adsorbates at the top most surface of the Si substrate in each spectrum were plotted against the corresponding values of theoretically calculated intensity which is given by the product of the ion fluence, the solid angle of the detector, the elastic scattering cross-section and the quantum efficiency of the detector, where it is assumed that the quantum efficiency is unity and the scattering cross section is calculated from the Thomas-Fermi approximation of the screened Coulomb potential. It was found from the plots that the experimental values deviate from the straight solid line of quantum efficiency=1 to the lower value with decreasing the incident energy. We estimated the quantum efficiency of the detector as a function of energy from the ratio of the experimental value to the straight line. The estimated values of the quantum efficiency for both He and D particles are shown as a function of their kinetic energy in Fig.1. It is seen from Fig.1 that the quantum efficiencies for He and D are unity above 1.3 keV and 0.9 keV, respectively.

Finally, it is noted that the use of microchannel plate for the detector provides with direct measurement of the energy spectrum of neutral particles of H, D and He emitted from the core plasma in the fusion devices, by means of the time of flight analysis.

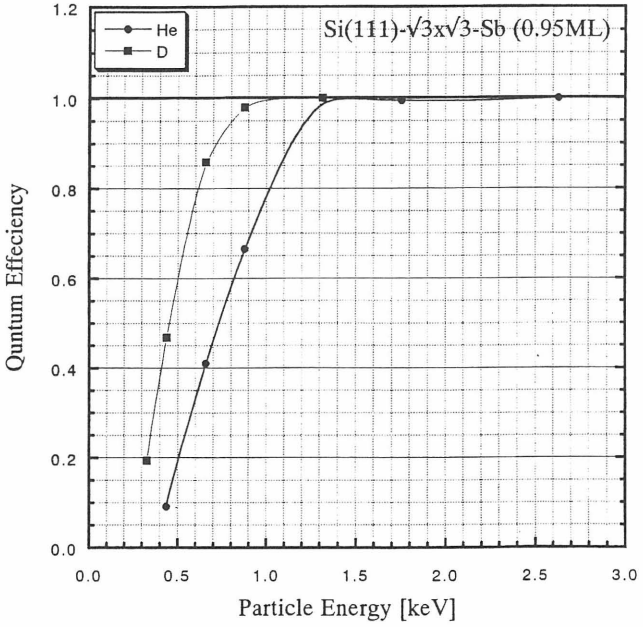

Fig.1. Quantum efficiencies of MCP(detector) for He and D particles as a function of their kinetic energy

Reference

1) Morita, K., Kishi, N., Grigoriev, A., Muroga, T., Masuzaki, S., Proc. of Int. Conf. on PSI-14 (Rosenheim, 2000)