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

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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 distribution 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 (H, D, and He). In order to use the microchannnel 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 the last year, we described 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 showed that the quantum efficiencies for He and D are unity above 1.3 keV and 0.9 keV, respectively and decreases gradually as their energies decrease. [1] For the next step, it is necessary to discriminate He, T, and D from among the neutral particles emitted from the D-T burning plasma. One of the most promising method for the particle discrimination is the ionization of neutral particles: one is laser ionization and the other is surface scattering.

In this report, we describe the experimental data on the ion fraction of the backscattering intensity of He^+ ions from monolayer metal adsorbates on the Si-metal ordered surfaces as a function of the incident energy which have been measured using the CAICISS system. [2]

The Si (111)-metal ordered surfaces were prepared by deposition of metal films of about one monolayer (1ML, 7.8×10^{14} atoms/cm²) in thickness onto the Si(111)-7×7 surface and subsequent heating for 10 min at 300℃. The thickness of metal films was measured by RBS, which is crucially important in the present study. The thickness of metal films was less than 1ML, thus suggesting that there were no metal islands on the Si (111)-metal ordered surfaces observed by LEED.

The time of flight measurements of particles reflected at an angle of ~180° from the specimen, irradiated with He^+ ions at different incident energies from 3.0 to 0.50 keV, were carried out using the CAICISS system. The ion component was separated from the neutral component of backscattering particles by biasing the target at positive voltages to the graphite aperture grounded, which was situated 10 cm in the front of the target surface.

The fraction of He^+ ions backscattered from different adsorbates are shown as a function of incident energy in Fig.1. It is seen from Fig.1 that the ion fraction from Ag increases very gradually with increasing the incident energy, while the ion fractions from the other adsorbates show oscillatory variations with the incident energy. The amplitude of the oscillatory variation increases as the energy level of outer-shell electrons in adsorbates tabulated in the right hand side of the figure becomes close to the energy level of the He 1s orbital. The fact indicates that the quasi-resonance charge transfer takes place in the impact collision between He^+ ion and the adsorbate atom at the surface.

Finally, it is noted that the use of Ag for ionization of He^0 is the most effective among the other adsorbates, since the absolute value of the ion fraction from Ag is about 1/3 and has no oscillations.

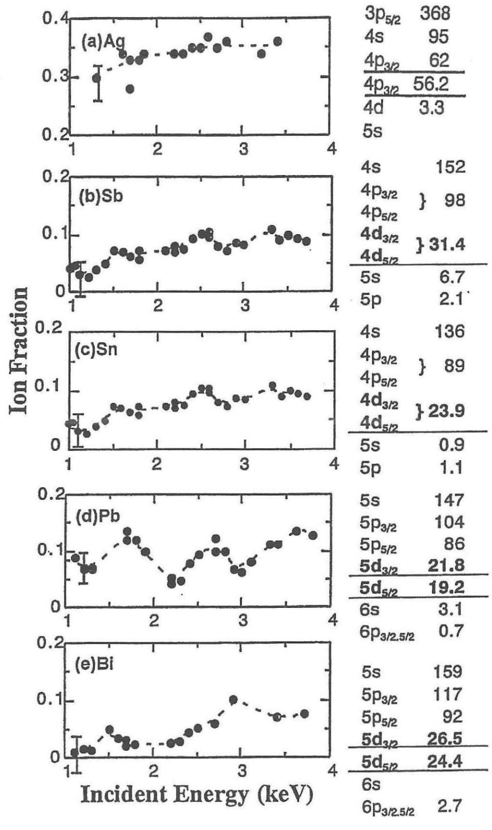

Fig.1 Ion fraction of the backscattering intensities of He^+ ions from monolayer metal adsorbates on solid surfaces as a function of the incident energy.

[1] K. Morita et al, J. Nucl. Mater. 290-293 (2001) 126-130
[2] K. Morita et al. 19th Int. Conf. Atomic Collisions in Solids (2001, Paris) Jul. 27-Aug. 3, to be presented.