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

Morita, K., Soda, K., Yagi, S., Yuhara, J. (Dept. Nlcl. Eng. Nagoya Univ.),
Tanabe, T., Muto, S., Yoshida, T. (CIRSE, Nagoya Univ.),
Masuzaki, S., Osakabe, M., Suzuki, H., Gotoh, T.,
Noda, N., Ohyabu, Y., 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 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 of the neutral particles is the time of flight (TOF) analysis. In the previous project, we have determined the absolute value of the quantum efficiency of the detector (microchannel plate) for neutral particles (H, D and He) in dependence on kinetic energy which is used in the TOF-neutral particle detection system.

The aim of this project is to discriminate He, T and D 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 and the post mass analysis in the TOF measurement: one of the ionization is laser ionization and the other is surface scattering under the specular reflection condition. The latter technique is the most appropriate for He because of its high ionization potential.

In this report, we describe the experimental data on the ion fraction of the backscattering intensity of He^+ ions from the insulating target (NaCl) as a function of scattering energy which have been measured using the CAICISS system. The effect of the charge accumulation at the surface on the ion fraction has been also investigated by biasing the secondary electron suppressor plate in the front of the target surface.

We have measured the backscattering spectra of 150 eV and 3000 eV He^+ ions from the NaCl crystal heated at different temperatures. Above 100°C, the spectra have been found to show no change, which indicates that the effect of the charge accumulation is the minimal. Thus, the backscatteing spectra from the NaCl crystal heated at 100°C have been measured at different bias voltages of the suppressor plate relative to the target, in order to separate the He^+ ion yield from the major He° neutral yield.

The typical backscattering spectrum of 3 keV He^+ ions from the NaCl crystal at room temperature and at no bias voltage is shown in Fig. 1 (a), where that at a bias voltage of 1400 V is also shown in Fig. 1 (b) for comparison. In Fig. 1 (a), a broad spectrum in the flight time between 7 and 11μsec represents the He° particles from Cl atoms of the NaCl crystal and a large narrow peak at the flight time of 12.4 μs represents the Na^+ ions sputtered from the target and accelerated by the charging-up voltage at the target surface. The charging-up voltage was estimated to be 1200 V from the peak flight time. The rising flight time of the broad peak was found to be consistent with the scattering energy, from the Cl atoms, of the incident He^+ ions decelerated by the charging-up voltage at the target surface. In comparison with Fig. 1 (a), it is seen from the spectrum at bias voltage of 1400 V that the new He^+ scattering yields appear at the shorter flight time (at the higher energy) and the Na^+ ion yield by sputtering is strongly reduced.

The time of flight spectra of He^+ ions and He° neutrals were separated from that in Fig. 1 (b) using the He° spectrum in Fig. 1 (a). From both spectra the absolute values of the ion fractions were obtained as a function of backscattering energy at the target surface. The ion fractions in the backscattering of 1.5 keV ions from the specimen heated at 100°C were also obtained for comparison. The experimental data for room temperature have shown that the ion fractions in the near 180°C backscattering of He^+ ions from the NaCl crystal increase gradually from 0.10 to 0.15 as the scattering energy increases from 500 eV to 1500 eV. The ion fractions from the NaCl crystal heated at 100°C have shown almost the same values as that at room temperature. The results are concluded to show that the insulator target enhances the ion fractions in the near 180°C scattering of He^+ ions.

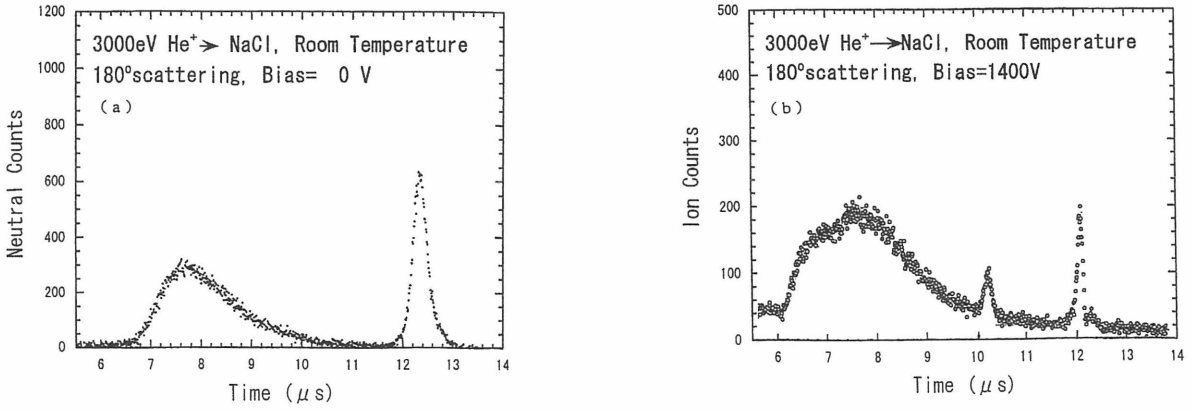

Fig. 1. TOF spectra for the near 180° backscattering of 3 keV He^+ ions from the NaCl crystal at room temperature at no bias voltage (a) and at a bias voltage of 1400 V (b).