§80. Surface Analysis of Effect of Plasma Irradiation to Nuclear Fusion Materials

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Development of materials suitable for divertor components is an essential issue for realization of fusion reactor. The objective of this study is to provide the basic data for material development by using high heat-flux plasma flow emitted from the large tandem mirror device. In this research, we irradiate the various materials that will become candidates of divertor components with plasma flow with high heat-flux emitted from the end-mirror throat of the GAMMA 10 tandem mirror and investigate the difference between the circumstances of the irradiation in the GAMMA 10 end-cell and those of actual divertor regions in tokamaks from the viewpoint of surface analyses.

In the GAMMA 10 west end-cell, the experiment of plasma irradiation was carried out at a horizontal port at the 70 cm downstream from the end-mirror coil (z_{EXIT}=60 cm). Figure 1 shows the photograph of the sample holder and the sample drive system. The sample holder is made of molybdenum and capable of mounting five samples. In this experiment, SiC, W and C samples are chosen as an irradiation specimens and the irradiation of end-loss plasma flow in standard hot-ion-mode plasmas (plasma density of the central-cell: ne_{CC} = ~2×10^{18} m^{-3}, T_i = ~5 keV) with the discharge duration of 400 ms was performed in a day (about 70 shots).

The surface analysis was performed by using the surface analysis system with high-energy He beam (2 MeV) at the Institute of Materials Research, Tohoku University[1]. Figure 2 shows the result of Rutherford backscattering spectra (RBS) in the two SiC specimens (as prepared / exposed to the plasma) in the case that the analyzing He beam is injected with the direction of <0001>. In the exposed specimen, as shown in the figure, Cr, Fe and Ni, which are component of the stainless steel, are detected together with a small amount of Mo and W. The total amount of deposited transition metal atoms on the SiC surface is roughly estimated to be 1×10^{20} atoms/m^2. These metal atoms are supposed to be coming from the wall materials of vacuum vessel.

The spectra of forward elastic recoil hydrogen (ERDS) obtained from the same specimens are shown in Fig. 3. A broad peak near the channel number of 370 corresponds to hydrogen located near the surface and the amount of deposited hydrogen is measured to be 5×10^{20} atoms/m^2 in the case of exposed specimen. It is expected that these hydrogen atoms are trapped in the deposited metal layer and/or the surface layer of SiC. It is also observed that the damage due to knock-on effect of the plasma flow.

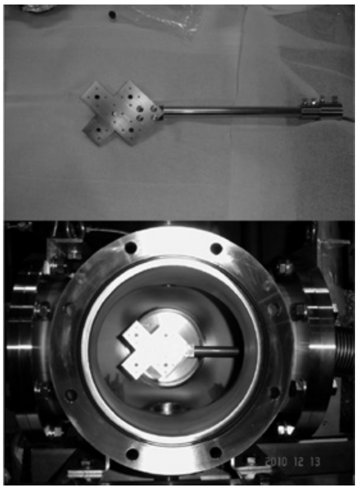

Fig. 1 Photograph of the sample holder and the sample drive system with the installed holder.

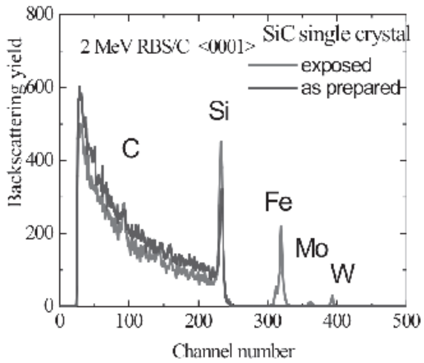

Fig.2 RBS results of irradiated SiC samples.

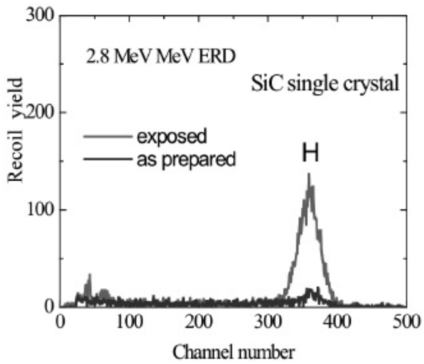

Fig. 3 ERDS result of irradiated SiC samples.

1) Nagata, S., et al., J. Alloys and Compounds **446-447** (2007) 558.

The publications from this collaborative research are listed below:

2) Nakashima, Y., et al., 3rd PRC Symposium, July 20-22, 2011, Tsukuba Science Information Center, Tsukuba.

3) Nakashima, Y., et al., Oaraki research meeting, Sept. 12-13, 2011, International Research Center for Nuclear Materials Science, Oarai.