§26. Estimation of CX Incident Parameter with Material Probes

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Material probe experiments have been employed as efficient methods to investigate the PSI phenomena in many plasma confinement devices. The present authors also performed the probe experiments from the viewpoint of microscopic damages in LHD and TRIAM-1M, and elucidated that charge exchange (CX) neutrals has large impacts not only on the surface modifications of PFMs (plasma facing materials) but also on plasma density controlling.[1,2] However, most of previous researches have dealt with the superimposed effects due to the exposure to plasmas in various conditions, and not examined the phenomena caused by specific plasma condition. In this study, therefore, effects under a certain plasma condition were clarified by a controlled material probe experiment, and CX incident parameters were evaluated quantitatively for each plasma condition. In addition, the availability of this method as CX- neutrals monitor was discussed.

To examine the modifications of PFMs due to CX-neutrals, pre-thinned samples (316SS, W, Mo and Cu) were exposed to identified plasmas by using retractable material probe holder with rotation shutter (Fig.1) to distinguish plasma. The samples were inserted in the inner wall level of vacuum vessel by using the material-probe system through the 4.5 low-port, and exposed to low density plasma (Shot No. 86192~86197) and high density plasma (Shot No. 86184~86189) for about 30s, respectively. After the exposure, the microstructure modification was observed by TEM and compared to results obtained by irradiation experiments to evaluate the CX incidence parameters.

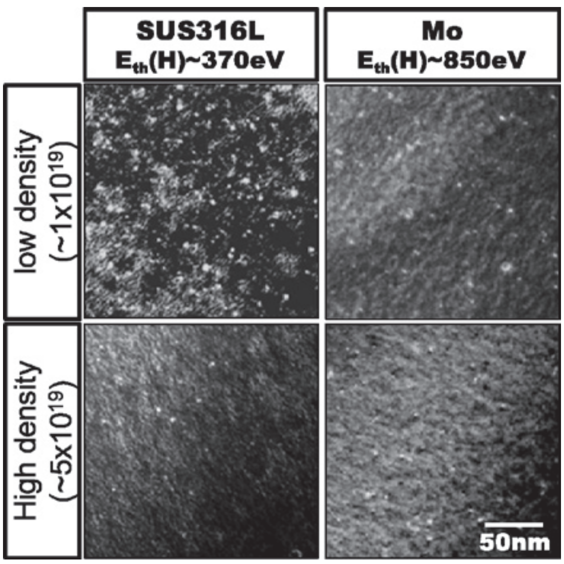

Fig. 2 Microstructure of material probes exposed to low density and high density plasmas for about 30 s.

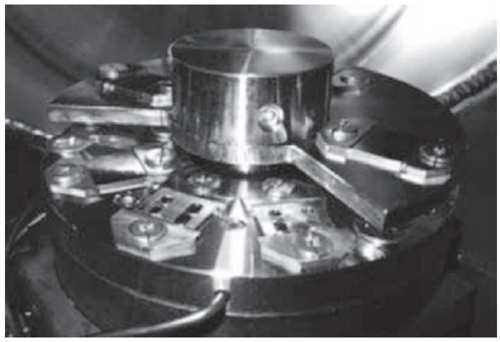

Fig. 1 The sample holder with a rotating shutter.

Microstructures of the probe samples exposed to LHD plasma showed significant dependence on the density of plasma. Fig. 2 shows TEM images of the SUS and Mo specimens, indicating the radiation-induced dislocation loops with white contrast. The damage density in the samples exposed to low density plasma was much higher than that in the sample exposed to high density plasma. By comparison of the LHD results with that of ion irradiation, fluence of high energy CX-neutrals, which could cause defects in SUS and Mo, were roughly estimated as shown in Fig. 3. As a result of the comparison in SUS, the fluxes were evaluated to be about 6.7×10^{19} and 2.6×10^{19} H/m^2s for low and high density plasma case, respectively. For Mo which has higher threshold energy of hydrogen for knock-on damage, 1.5×10^{19} and 0.9×10^{19} H/m^2s for low and high density plasma, respectively. Similar tendency was also expected from a modeling analysis of particle transportation.

While there is an accuracy limitation, it is important to mention here that this method has large benefit to evaluate the CX-particle load to first walls quantitatively just using small samples.

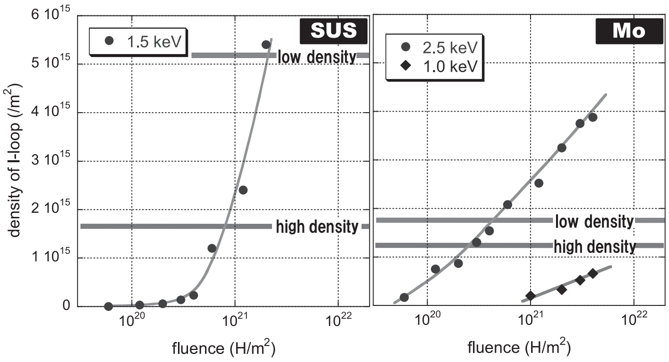

Fig.3 The comparison of damage densities between LHD material probes and irradiation experiment samples.

1) M. Miyamoto et al., J. Nucl. Mater. 337-339 (2005) 436
2) M. Tokitani et al., J. Nucl. Mater., 367-370 (2007) 1487