§65. Erosion of First Wall Materials under High Flux Beam Irradiation

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Plasma facing components (PFCs) are subjected tc high particle (heat) flux from edge plasmas and it is important to investigate erosion process and develop low erosion materials under such conditions. For this purposes, we have measured the erosion rate of graphite and doped graphite with high flux beam generator, the maximum flux of which is comparable to those from edge plasma conditions.

So far it is found that the erosion yield of graphite at elevated temperatures (1980 K) irradiated by 5 keV Ar beam at normal incidence significantly decreases with irradiation flux more than 10^{20} $m^{-2}s^{-1}$ regardless of graphite types (isotropic and pyrolytic). Under actual edge plasma conditions, magnetic field lines are almost parallel to the surface of PFCs and ions impinge on PFCs at oblique incidence. In this study, we investigate the angular dependence of erosion yield of graphite at elevated temperatures to provide the erosion database and to prove erosion mechanism of graphite (radiation enhanced sublimation, RES). Ir addition, we study ion irradiation effects on boron thin film formed by a vacuum evaporation method Boron films were formed by changing deposition rate, which is known to affect internal stress of the films.

Experiments were made with a high flux beam irradiation test stand in Osaka University. Irradiation was made with 5 keV Ar beam with the flux of about 10^{21} $m^{-2}s^{-1}$. Pulse length and duty of the beam were about 2 s and 80 s, respectively. Figure 1 shows angular dependence of erosion yield at 1980 K and RT. In the case of RT irradiation, the surface temperature of the samples increased up to 900 K. In this temperature range, the dominant erosion process is physical sputtering, while in the case at 1980 K radiation enhanced sublimation[1] is dominant.

For irradiation of IG430 (isotropic graphite, Toyo Tanso co.) at 1980 K, angular dependence of the yield is weak, but flux dependence was clearly observed in the similar manner to the results of normal incidence. It is also noted that the flux dependence of IG430 is similar for ISO-630 (isotropic graphite) and pyrolytic graphite (Union Carbide). For irradiation at RT, weak angular dependence of physical sputtering yield is observed.

The angular dependence of our experiments is much weaker than the model calculation. For physical sputtering, Yamamura's formula[2] gives stronger dependence with the maximum yield at about 75 degree of incidence. For RES, the angulaı dependence of the yield was calculated by using a simple interstitial diffusion model with the range calculation by TRIM92. Although the result shows much weaker angular dependence of RES than that of Yamamura's model, it does not account for almost no angular dependence of the experiments. The very weak dependence observed in the experiments could be attributed to the surface roughness of the sample.

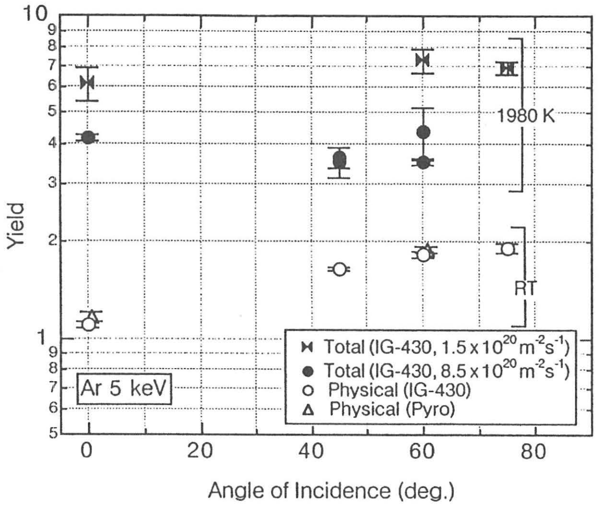

Fig.1 Yields of graphite vs. angle of incidence

Surface morphology of boron thin films show some differences with deposition rate. For low deposition rate (0.8 - 0.9 Å), spherical grains with a diameter of about 1 μm were observed on the surface, but not for high deposition rate (4.6 - 6.6 Å). Sputtering yield of the boron thin films by Ar irradiation did not show clear difference with the deposition rates.

References

[1] Y. Ueda et al., J. Nucl. Mater. 227 (1996)251.
[2] Y. Yamamura et al., IPPJ-AM-26 (June 1983).