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

Ueda, Y., Isobe, M., Nishikawa, M. (Fac. Eng. Osaka Univ.)
Noda, N.

In actual fusion reactors, ion flux into first wall materials are considered to exceed 10^{23} $m^{-2}s^{-1}$ with impinging energy less than 1 keV. Large tokamak experiments suggest that the erosion of graphite under such high flux condition is significantly suppressed compared with the results obtained by low flux beam irradiation tests. To clarify these nonlinear erosion and correctly evaluate the erosion rate of first wall materials, high flux irradiation experiments are important.

For that purpose, we fabricated high flux beam generator and have measured the erosion rate of graphite and boron doped graphite. High flux beam is obtained by geometrical focusing methods of broad beam extracted from bucket source[1]. The irradiation flux up to 10^{22} $m^{-2}s^{-1}$ (energy 1.7 keV) for D and 10^{21} $m^{-2}s^{-1}$ (energy 5 keV) for Ar are possible by the source, which is about two order of magnitude higher than the previous low flux beam source.

Figure 1 shows the results on chemical sputtering of isotropic graphite under deuterium irradiation. In previous low flux experiment, characteristic peaking of sputtering yield around 800 K due to the production of hydrocarbon was shown [2,3](chemical sputtering). However, our result indicates that the chemical sputtering peak is almost suppressed in high flux regime.

Figure 2 shows the erosion yield of isotropic graphite due to radiation enhanced sublimation (RES) at the elevated temperature. Previous low flux experiments[4] showed the weak flux dependence of RES yield as $\phi^{-0.07}$(ϕ, flux), while our experimental results shows clear reduction of RES yield as $\phi^{-0.26}$ in high flux regime.

In conclusion, we observed non-linear behavior of chemical sputtering and RES in high flux regime, which is qualitatively consistent with the results of the large tokamak experiments.

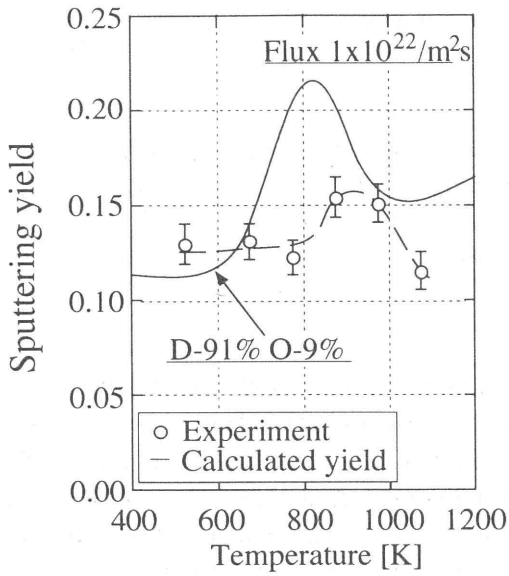

Fig.1. Sputtering yield of graphite by D beam (1.7 keV) with the flux of 1 x 10^{22} $m^{-2}s^{-1}$. The irradiation beam contained 9% of oxygen, which is considered when our experimental results and calculated results from the previous low flux experiments[2,3] are compared.

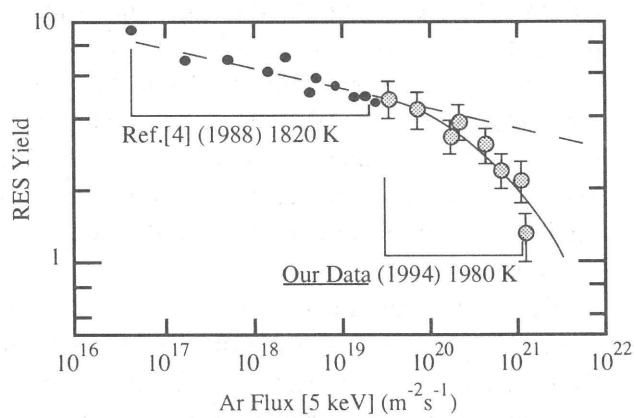

Fig. 2. Flux dependence of RES yield of graphite by Ar beam (5 keV). Reference data is arbitrary unit, while our data is absolute number.

References

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[4] Philipps, V. et al., J. Nucl. Mater. 155-157 (1988) 319.