§5. Sputtering Yield Formula for B₄C Irradiated with Monoenergetic Ions at Normal Incidence

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B₄C material is thought to be one of the potential candidates for plasma-facing materials in fusion devices.

To fill a lack in yield data for this material, sputtering yield was calculated for monoenergetic H⁺, D⁺, T⁺, He⁺, B⁺, C⁺, Ne⁺, Ar⁺ and Kr⁺ ions at normal incidence. The calculations were done for this multi-component material with a Monte Carlo code ACAT[1]. The calculated data were compared with experimental data. Good agreement was seen for H⁺, D⁺ and C⁺ ions except for slight differences for He⁺ and Ne⁺ ions between the ACAT data and the experiments. The case for D⁺ ion is shown in Fig.1, where the ACAT data are marked with stars and the experimental data with "A".

Based on a formula for monoatomic target materials at normal incidence[2], an empirical fitting formula for multi-component materials $Y(E)$ was proposed[3]:

$$Y(E) = 0.042 \frac{Q <\alpha> S_n(E)}{<U>} \frac{1}{1 + \Gamma <k_c \epsilon^{0.3}>} \left[1 - \sqrt{\frac{E_{th}}{E}} \right]^s, \quad (1)$$

where the factor has the following form:

$$\Gamma = \frac{W}{1 + (M_1/7)^3} \quad (2)$$

where M_1 and E are the mass in u and the incident energy of a projectile, E_{th} the sputtering threshold energy. Q , W , E_{th} and s are the fitting parameters of a target material. The other physical quantities bracketed with angle brackets in eq.(1) are defined in [3]. The fitting procedure of eq.(1) to the calculated data is also explained in [3]. The power s in eq.(1) for B₄C has a best-fit function of M_1 as shown in [3]. The best-fit values of Q and W

derived by these fits are 1.70 and 1.75. The best-fit values of E_{th} are presented in [3]. Through these fittings good agreement was achieved between the yield formula and the calculated data. Fitting to the D⁺ data is shown with a thick solid curve in Fig.1. Thus, the formula proposed for the multi-component material provides a way to estimate the erosion of a B₄C material irradiated with above ions at normal incidence. Fitting of the formula to the other multi-component materials is in progress.

Preferential sputtering was found for a B₄C material[3]. The result indicates that carbon atoms are hardly sputtered for incident energies lower than about 10² eV. A detailed study of this phenomenon for the material, in which changes of the surface composition due to ion doses are considered, is also in progress.

Fig. 1. Energy dependence of sputtering yield of B₄C with D⁺. The thick solid line means a yield curve with the best-fit threshold energy. $Q=1.70$, $<U>=6.09$ eV, $W=1.75$, $s=2.22$.

References:

- [1] Yamamura, Y. and Mizuno, Y., IPPJ-AM-40.
- [2] Yamamura, Y. and Tawara, H., At. Data Nucl. Data Tables 62 (1996) 149.
- [3] Ono, T., Kawamura, T., Ishii, K., and Yamamura, Y., J. Nucl. Mater. (1996) (in press)