§20. Response of Plasma Facing Materials by High Fluence Particle Irradiation

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One of the important research subject of the LHD project is to realize long pulse discharges with superconducting magnets. Erosion characteristics and hydrogen retention of plasma facing materials for the LHD must be evaluated by high flux and high fluence beam irradiation. For this purposes, we have measured the erosion rate of graphite (isotropic and C/C) with high flux beam generator, the maximum flux of which is comparable to those from edge plasma conditions.

In this study, we tried direct measurements of sputtered particles (methane) by using a quadrupole mass analyzer with a differential pumping system to obtain real time information of erosion characteristics. Experiments were made with a high flux beam irradiation test stand in Osaka University. Irradiation was made with 5 keV D_3^+ and H_3^+ beams (effective energy of one atom; 1.7 keV) with the flux of about 10^{22} $m^{-2}s^{-1}$. Maximum pulse length and duty of the beam were about 4 s and 80 s, respectively. Samples were heated by infrared heating device with the maximum temperature of 800°C. Samples were isotropic graphite (I430U) , CFC (CX2002) and boron doped graphite (GB series, B/C ~ 0% -20%).

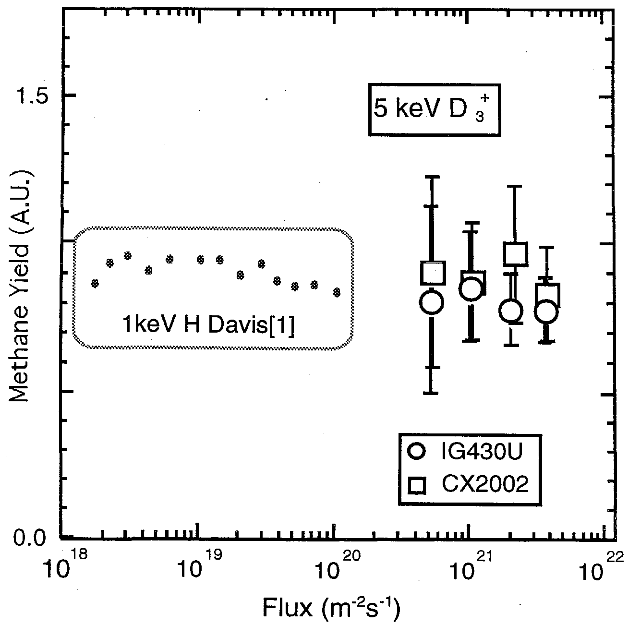

Fig.1 Flux dependence of methane yield

Dependence of methane yields on temperature and irradiation flux by chemical sputtering was measured. It was found that maximum methane yields did not show clear flux dependence as irradiation flux was changed from 0.5 x 10^{21} $m^{-2}s^{-1}$ to 4.0 x 10^{21} $m^{-2}s^{-1}$(Fig.1). In the previous study made by Davis [1], very weak flux dependence was also observed (1-3 keV H) in the lower flux region, which indicates that flux dependence of chemical erosion yield is very weak in the wide flux range up to 4.0 x 10^{21} $m^{-2}s^{-1}$ for the beam energy of about 2 keV. A peak temperature at which the yield took maximum shifted from about 900 K to 1000 K (Fig.2) in our experiments. These peak temperatures are much higher than those of low flux data (750 K -850 K). Flux dependence of peak temperature based on the chemical sputtering model proposed by Roth [2] are also shown in Fig.2. Our experimental results agree well with the model without annealing effects (dotted line).

Methane yield measurement was also made for boron doped isotropic graphite with boron concentration from 0% to 20%. The yield for boron doped graphite decreased by a factor of 2 - 3 compared to pure graphite. The boron yield was almost unchanged with boron content.

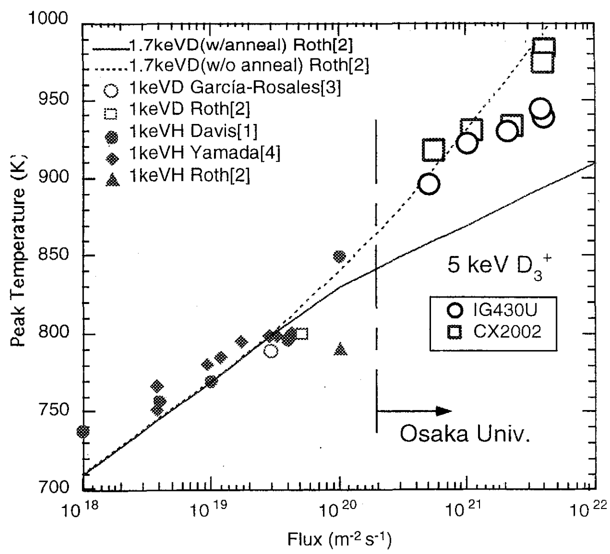

Fig.2 Flux dependence of peak temperature

Reference
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2) J. Roth, and C. Garcería-Rosares, Nucl. Fusion **36** (1996) 1642.
3) C. Garcería-Rosares, and J. Roth, J. Nucl. Mater. **196-198** (1992) 573.
4) R. Yamada, J. Nucl. Mater. **145-147** (1987) 359.