

## S9. Sputtering of Plasma Facing Materials by Irradiation with CW High Flux Ion Beam

Nishikawa, M., Horiike, H., Ueda, Y., Isobe, M., Ohtsuka, Y. (Fac. Engineering, Osaka Univ.), Morita, K. (Fac. Engineering, Nagoya Univ.), Yamamura, Y. (Fac. Informatics, Okayama Univ. of Science), Yoshida, N. (Res. Inst. Applied Mechanics, Kyushu Univ.), Motojima, O., Noda, N., Sagara, A.

For last several years, we have been studying plasma material interaction with high flux ion beam device with the flux of about  $10^{22} \text{ m}^{-2}\text{s}^{-1}$ , which is about two orders of magnitude higher than conventional mass-analysed ion beam device and is close to actual ion flux to plasma facing materials. Although new findings on graphite erosion characteristics by high flux beam irradiation were obtained [1,2], this high flux device can be operated only in a pulsed mode ( $< 4 \text{ sec}$ ) and it is not suitable for the study of plasma material interaction in a steady state. For this purpose, we have developed a new ion source device with triode spherical electrodes (HiFIT, High Flux Irradiation Teststand), which is shown in Fig. 1.

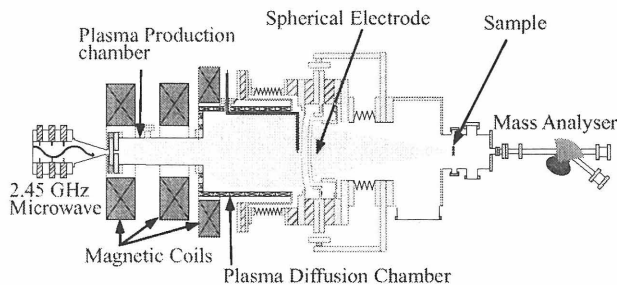


Fig. 1. Schematic view of HiFIT (High Flux Irradiation Test stand).

High density source plasma is produced by ECR discharge with 2.45 GHz microwave in a plasma production chamber. Maximum magnetic field of about 2.0 kG can be applied. In general, plasma density is increased with microwave input power until its saturation value. This saturation value increases with magnetic field in higher magnetic field than the resonant field (875 G). This suggests that non-resonant plasma production mechanism might be effective.

To obtain uniform plasma on spherical electrode (effective diameter of 15 cm), high density plasma is diffused into a plasma diffusion chamber where permanent magnets are attached outside to form line cusp field. Uniform plasma density was obtained at the position 1 cm from the electrode.

Discharge gas was fed near the microwave input window. The gas pressure in the plasma diffusion chamber can be reduced to about 1.5 mTorr for hydrogen discharge.

Broad ion beam is focused geometrically by multi-aperture triode spherical electrode whose effective diameter and radius of curvature are 15 cm and 60 cm, respectively. Maximum acceleration and deceleration voltages are 6 keV. For relatively high energy ion beam extraction ( $> 1 \text{ keV}$ ) deceleration voltage is kept lower than acceleration voltage, while for low energy beam extraction ( $< 1 \text{ keV}$ ) higher deceleration voltage is applied to obtain high flux beam.

Beam power on-axis measured by calorimeter at the focal point is shown in Fig. 2 for hydrogen discharges with the gas pressure of 2 mTorr.

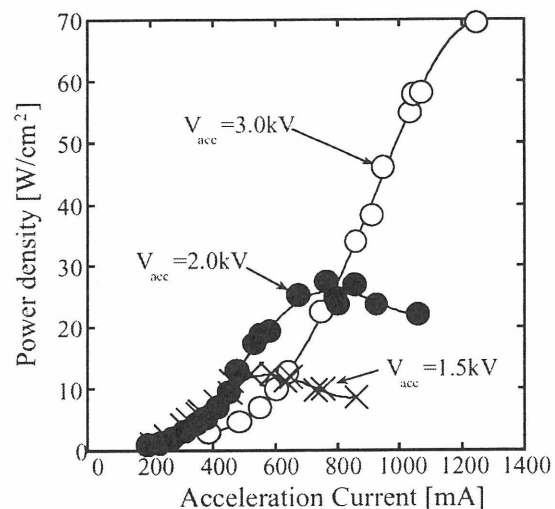


Fig. 2. Beam power density on-axis at a focal point  $P_{\text{axis}}$  as a function of acceleration current. The ratio of deceleration voltage to acceleration voltage is fixed at 0.2.

For the acceleration voltage  $V_{\text{acc}}$  of 1.5 kV and 2.0 kV,  $P_{\text{axis}}$  increases almost linearly with acceleration current  $I_{\text{acc}}$  until it shows saturation over some critical value of  $I_{\text{acc}}$ . This critical  $I_{\text{acc}}$  is about 450 mA for  $V_{\text{acc}}$  of 1.5 kV and about 700 mA for  $V_{\text{acc}}$  of 2.0 kV. These critical  $I_{\text{acc}}$  are roughly proportional to  $V_{\text{acc}}^{3/2}$ . Since  $I_{\text{acc}}$  is limited to about 1300 mA due to power supply limitation,  $P_{\text{axis}}$  for  $V_{\text{acc}}$  of 3.0 kV does not show saturation. According to the scaling of the critical  $I_{\text{acc}} \propto V_{\text{acc}}^{3/2}$ , the critical  $I_{\text{acc}}$  for  $V_{\text{acc}}$  of 3.0 kV could be around 1300 mA. So far maximum power density for  $V_{\text{acc}}$  of 3.0 kV is about  $70 \text{ W/cm}^2$ , which corresponds to the equivalent current density of about  $23 \text{ mA/cm}^2$ . In this case, hydrogen flux is about  $\sim 1.5 \times 10^{21} \text{ H/m}^2\text{s}$ , if all of ions are  $\text{H}^+$ .

### References

- [1] Y. Ohtsuka et al., J. Nucl. Mater. 220-222 (1995) 886.
- [2] Y. Ueda et al., J. Nucl. Mater. 227 (1996) 251.