§27. Experimental Study on Heat Flux of Divertor Plasma (Measurement of Fluctuation and Heat Transport in the Edge Plasma of Heliotron J Device)

Matsuura, H. (Osaka Pref. Univ.), Ohshima, S., Hashimoto, K., Okada, H., Kobayashi, S., Mizuuchi, T. (Kyoto Univ.), Nagaoka, K., Mutoh, T.

In 2010FY experiment, a new hybrid probe was constructed and tested with Heliotron J edge plasma for the first time. Its body is made of boron nitride (BN) and equipped with four conventional Langmuir probe tips and a temperature gradient type thermal probe (GTP) tip made of copper (Cu). The size of Cu tip is set as small as possible to improve time response.[1] So its fabrication was very difficult task and the setting of GTP tip is possible only along the axial direction of a large probe head (see Fig. 1). Whole probe system was connected to the driving system at the port 8.5 in order to study the edge plasma around X-point of the last closed flux surface of Heliotron J. From Langmuir probes, important data on long distance correlation of the floating potential fluctuation.[2]

Unfortunately, thermocouple signal shows much noise and no temperature increase even when BN cover suffers heat damage. This hybrid probe is driven in the axial direction to the last closed flux surface and magnetic field lines inside of the last closed surface crosses the side surface of the probe head. So plasma heat flux is expected to be hindered by BN head to reach the Cu GTP and S/N ratio is not so good. For Heliotron J condition, electrons with small gyro radius could not reach GTP and only ion heat flux can be measured. This situation is similar with those of the so-called ion sensitive probe. In order to study the plasma behavior and to confirm this hypothesis, simulation with XOOPIC code was done. XOOPIC is PIC simulation code developed in PTSG laboratory of UCBK.

Figure 2 shows its geometry model. Although the Cu GTP is a axis-symmetric cylinder, simple 2D geometry which is homogeneous along y direction was used for simplicity. Magnetic field ($\vec{B}$) is along x-direction and Cu surface is set at backside of BN cover about by ion Larmor radius. This is the same as those used in Heliotron J, although the small incline to side surface of BN cover (z-component of $\vec{B}$) is ignored to enhance shielding effect of $\vec{B}$ in the simulation. After the simulation starts, ions and electrons flows from there boundary but electrons are hindered to reach Cu sensor surface. According to the simulation progress, ions accumulates on the Cu surface and its electric potential becomes higher than plasma space potential (see Fig. 3), since Cu GTP was used in the floating condition (disconnected to the ground). Finally ions are also rejected electrostatically This results confirms our hypothesis

In the original design of the hybrid probe, this configuration was chosen to prevent from heat concentration on the edge of Cu sensor. Even with this, if potential control of the sensor is applied, ion heat flux might be measurable.

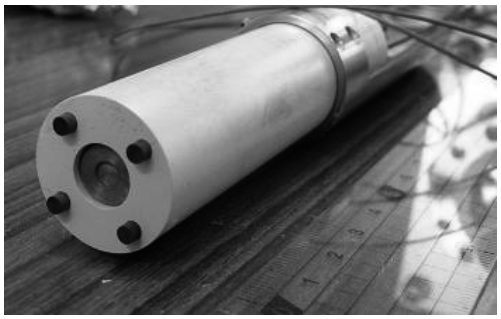

Fig. 1: Photo of the combined probe with a Cu GTP tip.

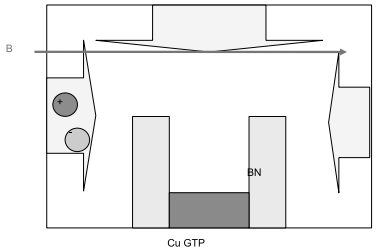

Fig. 2: Constructed calorimeter head.

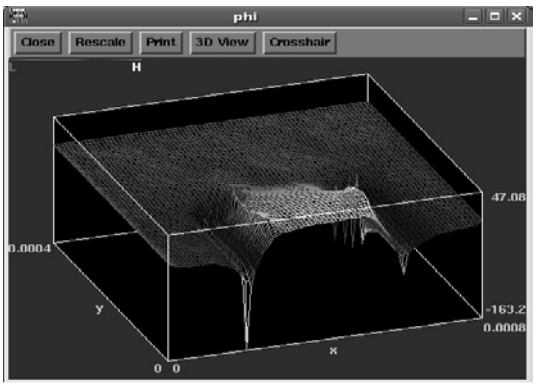

Fig. 3: Schematic drawing of the old calorimeter head (left figure) and the new one (right).

1) H.Matsuura *et al.*, Ann. Rep. NIFS, Apr.2011-Mar.2012(2012)492.

2) S.Ohshima *et al.*, 24th IAEA Fusion Energy Conference, (San Diego, USA, 2012 Oct.) EX/P4-17.