§26. Measurement of the Heat Flux Change Due to Confinement Transition in Heliotron J

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In order to estimate divertor heat load, a simple formula $q = \gamma T_e I_{is}$ has been used. However, relationship between the heat flux and the plasma parameters is very complicated. Thus, to check proposed methods to reduce the divertor heat load, the direct measurement of the heat flux is indispensable. Thermal probe method, in which the heat flux value to the probe tip is evaluated from surface temperature data and steady state heat balance relation, is the most promising, but the time response of thermal probes is rather poor. In order to overcome this drawback, we proposed the concept of the temperature gradient type thermal probe(GTP). As shown in Fig.1, GTP has two or three thermocouples and detects the one-dimensional temperature gradient (that is, conductive heat flux) in a probe tip, and deduce plasma heat flux without steady state requirement.

In this work, two kinds of GTP ware constructed. One has the GTP tip made of copper and consists the hybrid probe system with four conventional Langmuir probe tips(see Fig.2). The size of Cu tip is set as small as possible(about same as the scale indicated in Fig.1) to improve time response. So its fabrication is very difficult task and the setting of GTP tip is possible only along the axial direction of a large probe head. Since the whole probe system is driven in this radial direction and magnetic field lines crosses along the radial direction, plasma heat flux is hindered to reach the Cu GTP tip surface. So it is still important to improve S/N ration and to optimize the GTP design.

Another GTP was made of Pylex Glass, which has much smaller heat conductivity. This make them possible to extend the GTP applicable limit to low density glow discharge plasma, to find the origin of measurement error easily, and to make optimization study of the GTP design. As is already reported[1], especially for high pressure discharge, the axial heat transfer in a cylindrical probe tip is lost and the radial heat transfer makes an exact heat flux estimation difficult. So improvement of the radial thermal shielding is the most important issue.

To do this, the two dimensional PIC simulation code(Berkeley Code: XOOPIC) was used. Figure 3 shows the simulation model for the GTP peripheral region. Ions and electrons are introduced to the domain through the left and top boundary. The distance ℓ_z between the left boundary and the tip head must be kept smaller than a critical value, if the system is to reach the steady state. This constrain was confirmed with a 1D simulation and a kinetic theory based upon the generalized bohm condition. Similar constrain is needed also in r direction model size.

The shield is expected to hinder heat influx along the radial direction of the probe tip. The gap distance ℓ_z must not become too large, while thermal isolation is improved for large ℓ_z. So the optimum value of ℓ_z exits. Other design parameters are also examined. Considering the simulation results, a new probe tip and shield are constructed, and experimental test is also now underway.

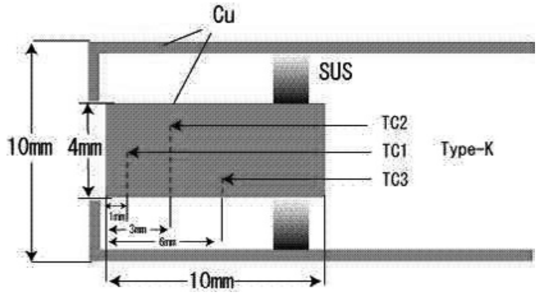

Fig. 1: Schematic drawing of the GTP tip and shield.

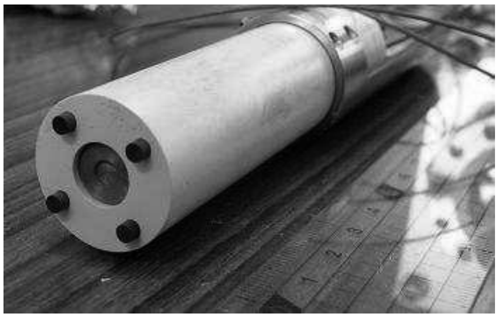

Fig. 2: Photo of combined probe with a Cu GTP tip.

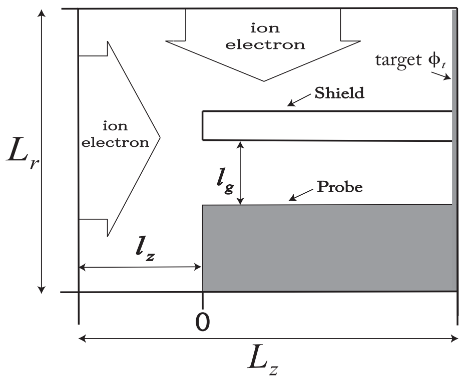

Fig. 3: Xoopic simulation model for the GTP tip and shield.

1) H.Matsuura *et al.*, Jpn. J. Appl. Phys. (2020) vol.49 08JD03.