§51. Langmuir Probes for the LHD

Masuzaki, S.

In order to measure the edge plasma parameters, two types Langmuir probes will be installed in LHD. One is the fast scanning probe and the other is the attached probes on the divertor tiles.

The fast scanning probe (FSP) will be installed from the lower measurement port as shown in Fig. 1, and measure the profiles of electron density, temperature and potential, and their fluctuations. The gate valve of the FSP is located inside the vacuum vessel, at the top of a tube (1.8 m of length, 197 mm inner diameter). All parts of the FSP are put in a tube. This metal sealed gate valve is developed for the FSP. Its hole (ϕ 39 mm) is in the center of the gate valve. The plasma facing surface is water cooled to reduce the temperature rise by the radiation from the plasma. There are two types of moving parts. The fast part is driven by a compressed air cylinder, and the moving length is 0.6 m. The slow part is driven by two hydraulic cylinders, and the moving length is 1.3 m. The feature of this hydraulic cylinder is that the rod is fixed and utilized as a linear way, and the cylinder part moves on this rod. The moving test of the fast part was done. It took about 0.3 sec for one way moving. As shown in Fig.1, the FSP can reach the last closed flux surface (LCFS). In the case of right position in Fig. 1, the slow part must stay in divertor leg to measure near the LCFS. It is difficult because of the high heat load, so this measurement is only possible in low additional heating power operation In the case of the left position in Fig. 1, the FSP can reach the LCFS near the null point only by the fast move. So the first FSP will be installed in this position. In a local island divertor (LID) operation, the FSP can measure the plasma parameters inside the m/n = 1/1 island easily. The probe tip is replaceable, and the measurements using multi electrodes type probes or multi grid electrostatic energy analyzer are in the planning stage.

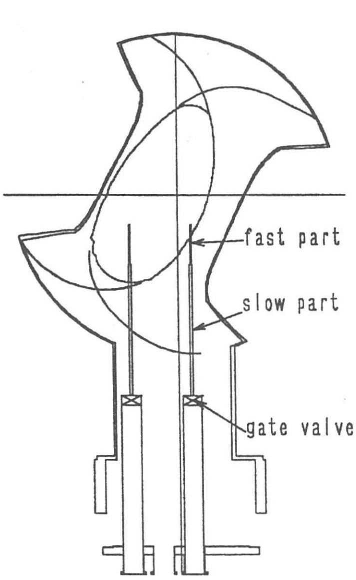

Fig. 1. The fast scanning probe (FSP) in the LHD. Two positions of the FSP are indicated.

The attached probes on the divertor tiles (APs) areutilized to measure the plasma parameters just in front of the divertor tiles. The measurement of the particle and the heat flux profiles on the divertor tiles using IR TV is one of the main purposes of the APs. The insertion of Fig. 2 shows the first design of the AP. The APs are exposed to the particle and heat flux to the divertor tile. So the material for APs must be choosen suitably. The materials of the probe tip, electric insulator and feedthru are C/C composite, boron nitride (BN) and molybdenum, respectively. The C/C composite has good heat conductivity (390 W/mK), and BN has also relatively good heat conductivity (60 W/mK). Molybdenum has the thermal expansion of ~ 5×10^{-6}/K which is nearly equal to that of graphite. The feedthru is screwed in the probe tip. The support plate is screwed on the divertor tile, and it fixes the AP. An active cooling is not applied to APs, so the APs are cooled by mainly heat conduction to the active cooled divertor tile through the electric insulator and radiation. The heat load test was performed using electron beam in the ACT device. Two APs are attached on real size divertor tile. Figure 2 shows the result of the test. In this case, the temperature difference beween the divertor tile and AP is about 200K for the heat load of 0.75 MW/m² corresponding to the forecasted heat load in 3 MW heating steady state operation of the LHD. The interesting point is that the AP temperature decreases immediately to the tile temperature after terminating the electron beam. It means that the heat conduction between tile and AP through the BN electric insulator is good. The probe tip diameter is 6 mm in the first design. Now smaller tip is under design to obtain the fine spatial resolution. The APs' signals are taken out using the MI cables which are laid under the divertor tiles.

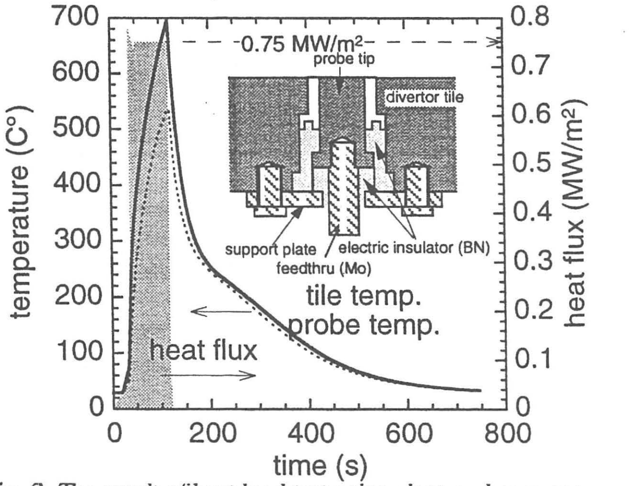

Fig. 2. The result of heat load test using electron beam per bmed in the ACT device. insertion: first design ofattached probe on the divertor tile.