§22. System Upgrade for the Electrode Biasing Experiment in LHD

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An electrode biasing experiment is one of the active control methods of radial electric field. The electrode biasing experiment has the advantage of ability to control radial electric field externally by controlling the electrode voltage and/or the electrode current and to estimate the driving force from the electrode current.

Since 2006 electrode biasing experiments have been carried out in LHD as a collaborative research between NIFS and Tohoku University in order to investigate a role of an ion viscosity for a transition to improved mode in toroidal systems.

In 2007 we faced several problems during the experiments as follows;

(1) Higher floating potential of the target plasmas for applying enough voltage using an existing power supply,
(2) Plasma collapse due to the electrode insertion to plasmas,
(3) Thermal damage of the insulation pipe of the electrode by the heat load from plasmas.

In order to solve above problems, we redesigned the electrode and upgraded the biasing experiment system.

First we prepared the higher-output power supply, which has the capability of 600 V-100 A (30 ms), for electrode biasing. The edge floating potential of the target plasma was confirmed to be ~150 V at the experiments in 2007, thus the power supply was expected to apply an effective bias voltage up to ~450 V.

Next we modified the electrode shape. We have been using the carbon disc for the electrode due to the high melting point and the low mass density. The electrode head was downsized in the diameter from 120 mm to 100 mm. It would decrease the perturbation to plasma and the risk of plasma collapse. Also we carried out the conditioning of the electrode surface by glow discharge to reduce the impurity emission.

The electrode was set on the driving apparatus at 4.5L port and was electrically insulated from the driving apparatus using insulation pipe. After the experiments in 2007, it was confirmed that the insulation pipe of Al_2O_3 was damaged locally by the heat road from the plasmas. Thus we replaced the pipe with BN (Boron Nitride), which has better thermal property than that of Al_2O_3. We used highly-pure BN with the melting point of more than 3000 deg, the thermal conductivity of 75 W/mk and the coefficient of thermal expansion of 0.86×10^{-6} deg^{-1}.

We tried to bias the electrode positively and to drive positive radial current by electron collection. We carried out the biasing experiments using these newly installed systems. The target plasma was produced and sustained by ECRH (~100 kW) under the magnetic configuration of R_{ax} = 3.6 m, B_t = 2.75 T and the typical plasma parameters are T_{e0} ~ 0.6 keV, n_e ~ 2.3×10^{18} m^{-3}. The electrode was set at ρ = 0.8 and was biased against the vacuum vessel. We confirmed that the electrode current of 35 A was applied by the bias voltage of 75 V. However it was concluded that we could not drive the radial current because there were no response of the plasma parameters during biasing and the evaluated plasma resistance was quite smaller than that obtained at the experiments in the previous year as shown in Fig. 1. Therefore, we had to assume the electrode current was applied in the bias circuit. It was thought that the problem was caused by the low charge resistance of the power supply.

On the contrary, we confirmed that the plasma collapse was not occurred through the experiments even the electrode was inserted to ρ = 0.8, and the thermal damage of the insulation pipe of the electrode was not observed. Thus the desired effects from the downsizing electrode and the replacement of the insulation pipe with BN were thought to be successfully achieved.

In future work, we are planning to replace the power supply with 650 V-23 A one manufactured by Matsusada Precision, which the lower-end model (150 V-75 A) was proven for the biasing experiments for LHD in 2007.

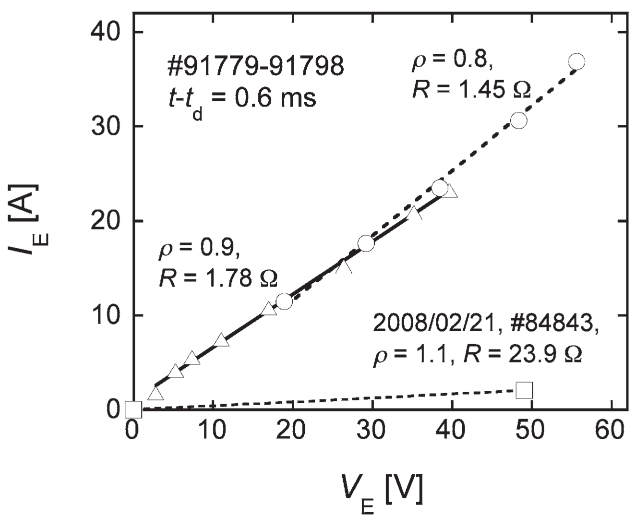

Fig. 1. The dependence of the electrode current I_E on the electrode voltage V_E obtained in the 2007 (squares) and the 2008 (circles and triangles) experimental cycle.