§29. Radial Electric Field Control by Electrode Biasing in LHD

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The transition to the improved confinement mode by the electrode biasing was observed for the first time in the Large Helical Device (LHD). The negative resistance was observed in the confinement mode sustained by the cold electrode biasing. The electrode current showed the clear decrease against to the increase in the electrode voltage and had hysteresis in the transition phenomena. The decrease in the electrode current suggested the improvement of the radial particle transport. The increase in the energy confinement time and remarkable suppression of the density fluctuation correspond to the transition were also observed. These results indicated that the electrode biased plasma in LHD showed the similar improvements in confinement to the observations in the H-mode plasma in tokamaks and stellarators[1-4].

The target plasma for the biasing in LHD was produced by ECH (f = 77 GHz, P_{ECH} ~ 0.25 MW) in the magnetic configuration (R_{ax} = 3.60 m, B_t = 2.75 T). The electron density and temperature at the magnetic axis were ~ 8×10^{18} m^{-3} and ~ 0.8 keV in the Helium target plasma. The electrode was a cylindrical disk of diameter 100 mm and length 40 mm, made of Carbon and inserted to r_E ~ 0.8. Figure 1 shows the typical time evolutions of (a) the electrode voltage V_E, (b) the electrode current I_E, (c) the electron density n_e at the magnetic axis and (d) the energy confinement time estimated from W_p /(P_{ECH} + $I_E V_E$ - dW_p/dt). The stored energy W_p was measured by the diamagnetic loop. The ECH was applied from t = 0.21 s to t = 1.21 s. The electrode was positively biased through the power supply (P_{out} ~ 3 kW) by the triangle input waveform for the power supply t = 0.9 s to t = 1.1 s as shown Fig. 1(a). In the ramp down electrode voltage case the electrode voltage did not follow in the input waveform because of the time response characteristics of the power supply.

Figure 1(b) shows the sudden current drops (0.99 s < t < 1.06 s) in the electrode current, which means the *negative resistance* and suggested the transition to another confinement mode. Figure 2 shows the relation between the electrode voltage and the electrode current. The rectangle symbols show the fixed voltage biasing cases in which the electrode was biased by the rectangle waveform. In this case the electrode characteristics also shows the negative resistance, however the fixed voltage biasing was not convenient for the survey of transition points. Therefore we adopted the triangle waveform for the biasing shown in Fig. 1(a). The solid line shows the triangle waveform case. It clearly shows the transition points and the negative resistance characteristics, which suggests the improvement of the radial particle transport. The electrode voltage at the forward transition (V_E ~ 470 V) was greater than that at the reverse transition (V_E ~ 430 V). Therefore the electrode characteristics had the *hysteresis* in the transition phenomenon. In Fig. 1(d) the energy confinement time increased about 8 % correspond to the transition.

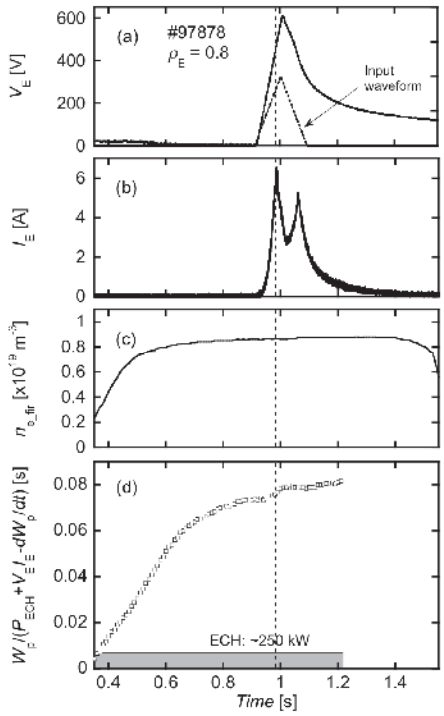

Fig. 1 The typical time evolutions of (a) the electrode voltage V_E, (b) the electrode current I_E, (c) the electron density n_e at the magnetic axis and (d) the confinement time

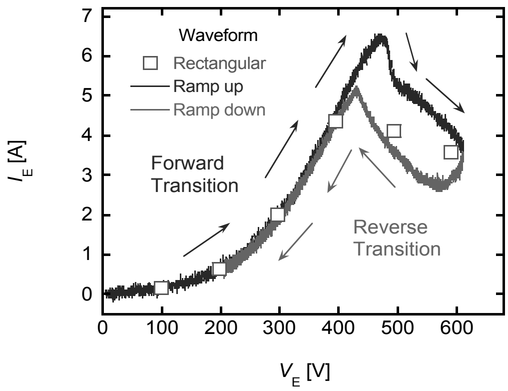

Fig. 2 Relation between the electrode voltage V_E and the electrode current I_E

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