§21. Study on Electric Field and Density Transition Phenomena in Magnetized Plasma

Shinohara, S., Itagaki, N., Ichiki, R.
(Interdis. Grad. Sch. Eng. Sci., Kyushu Univ.),
Fujisawa, A., Ida, K., Iguchi, H.

Transport barrier and its formation mechanism have been actively investigated in NIFS, and advancing these understandings is crucial in the future nuclear fusion studies. Plasma rotation driven by so-called $\boldsymbol{E}\times\boldsymbol{B}$ drift has been also studied in relation to improvement of the magnetic confinement. Therefore, investigations of the characteristics of the electric field and its effect on transition phenomena are very important.

Here, we studied the density transition phenomena along with plasma rotation and density profile modification [1-4], using ten concentric circular rings as biased electrodes. Argon plasma at a pressure P of 0.1 - 10 mTorr in the cylindrical chamber, 45 cm in diameter and 170 cm in axial length, was produced by a RF wave of 7 MHz using a spiral antenna. Plasma parameters were measured by Langmuir probes, and the plasma flow by the Mach probe (directional probe). Typical plasma density n_e and electron temperature were 4×10^9 - 4×10^{10} cm^{-3}, 3 - 6 eV, respectively.

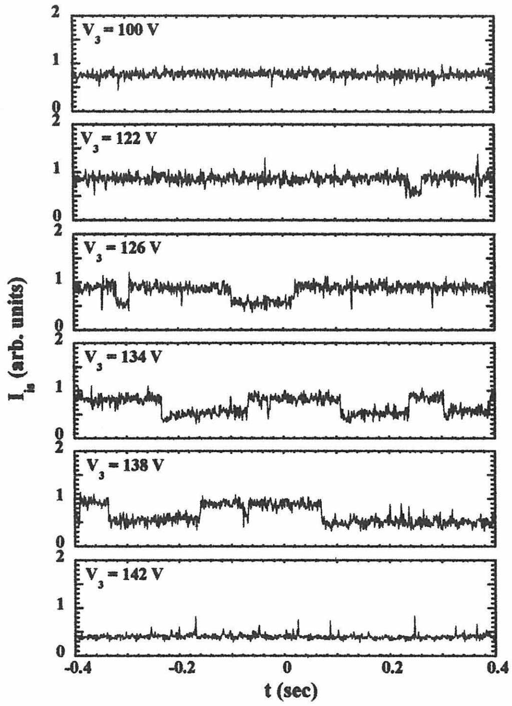

Fig. 1 Time evolution of ion saturation current, changing bias voltage.

Changing biased voltage, fill pressure and biased position, global structural changes of plasma parameters such as plasma density, floating potential and azimuthal plasma rotation were investigated. As shown in Fig. 1, repeated transitions phenomena with abrupt reductions and jumps of the electron density were observed (flip-flop pattern in bistable system). With the increase in the bias voltage, possibilities to possess one state (state II, lower density) compared to the other state (state I, higher density) increased. These global, self-excited, density transitions and back ones between two states were accompanied by changes of the floating potential and rotation profiles and the bias current under various parameters.

Figure 2 shows the characteristics of transitions as a function of fill pressure: bias voltage V_3 (applied at the electrode No. 3) and average staying time at a state II were measured. Here, closed circles, open triangles and closed boxes show, respectively, points of the onset from states I to II, points of 50 % staying probability (of time) for each state, and points of the onset of full transitions to the state II. Average staying time T_a in Fig. 2 (b) is defined as the total staying time at the state II divided by frequency (number of events) during observation time, for the case of 50 % staying probability for both states of I and II. This T_a was derived under the same condition as open triangles in Fig. 2 (a). Voltages for transitions decreased with P, while T_a became minimum at $P\sim2.5$ mTorr.

In conclusion, we have investigated the detailed characteristics of density transitions (bistable sytstem) in a wide range of operational parameters.

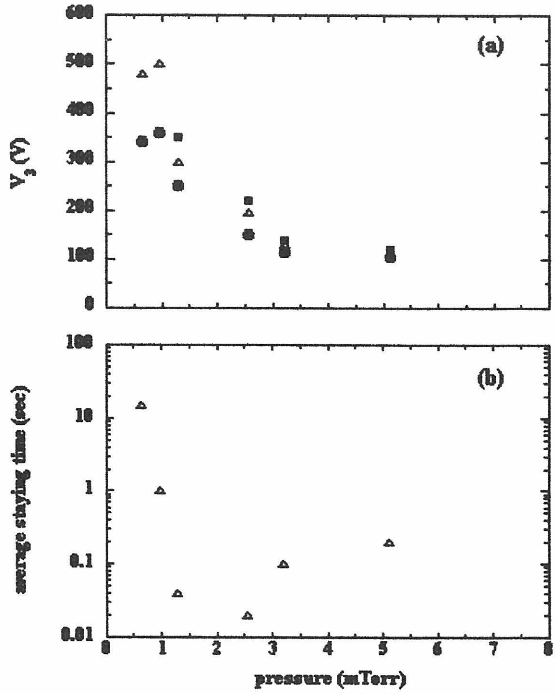

Fig. 2 Dependences of (a) bias voltage for transition regions and (b) average staying time on fill pressure.

Reference

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