§16. Dynamic Control of Bifurcated Transition in Magnetized Plasma

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In NIFS, transport barrier and its formation mechanism have been actively investigated, and understanding of them are 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 dynamic process of the electric field and its effect on transition phenomena are very important.

We have been trying to control the density transition phenomena along with plasma rotation and density profile modification, using ten concentric circular rings as biased electrodes [1-3]. Here, dynamic changes of plasma performance were studied by applying the steady or pulsed bias voltages. 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 a developed 24 ch. Langmuir probe and a 3D scanning probe [3]. Data were stored with a data logger. Using this system, detailed spatio-temporal behavior was investigated. Typical plasma density n_e and electron temperature were 4×10^9 - 4×10^{10} cm^{-3}, 3 - 6 eV, respectively.

Applying a pulsed bias voltage from the low to the high voltages to satisfy the change from state I only (high density) and state II only (low density), different time responses were observed, as shown in Fig. 1. Here, the spatio-temporal behaviors from sate I to sate II of the ion saturation current I_{is} and the floating potential V_f are shown. Although the change of bias voltage is less than μs, I_{is} in the bulk plasma region changed slowly with less than ms. On the other hand, the bias current I_b, which is the electrode current, changed very fast with less than 10 μs. Here, V_f in the bulk region changed much slower on the order of ms. Note that, near the electrode region, I_{is} and V_f changed fast with less than a few tens of μs [4]. In addition, we have observed the hysteresis characteristics [4] in a statistical sense, which is different from the dc hysteresis, as is shown in Fig. 2. Here, PDFs (probability distribution functions) were different between the increasing and decreasing phases of the bias voltage: probability having state II in the increasing phase is lower than that of state II in the decreasing phase.

In conclusion, we have investigated the detailed spatio-temporal characteristics of density transitions by voltage biasing, and found the stochastic hysteresis. Obtained results suggest that the plasma parameters near the electrode play an important role causing the transition, which may be interpreted from the particle. These understandings will be expected to contribute to the plasma confinement and stability control.

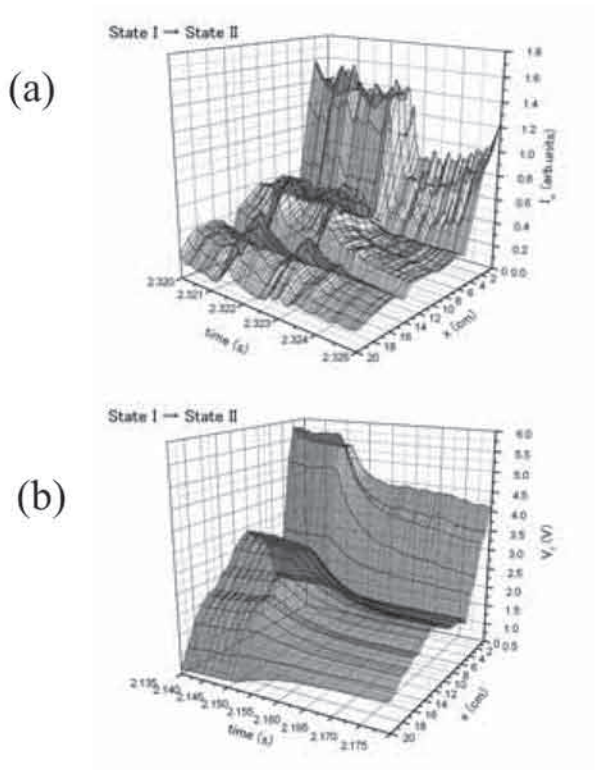

Fig. 1. Spatio-temporal behaviors of (a) I_{is} and (b) V_f

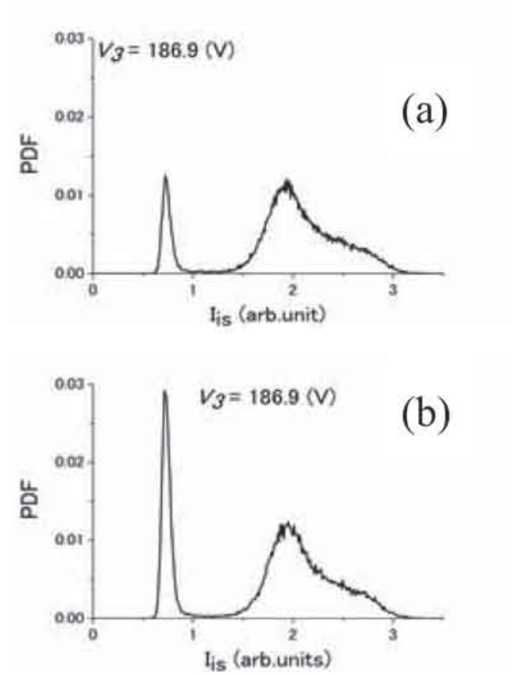

Fig. 2 PDFs in the (a) increasing and (b) decrresing phases of bias voltage.

References
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