§15. Study on Control of Bifurcated Transition in Magnetized Plasma

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Understandings of transport barrier and its formation mechanism, which have been actively investigated in NIFS, 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 characteristics of the electric field and its effect on transition phenomena are very important.

We have been trying to control the density transition phenomena[1,2] along with plasma rotation and density profile modification,[1,3-5] using ten concentric circular rings as biased electrodes. Here, dynamic changes of plasma performance were studied by the pulsed bias voltage. 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.[6] 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. Although the change of bias voltage is less than μs, the ion saturation current 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, the floating potential 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. In the case that the pulse width was reduced to 5 μs, as is shown in Fig. 2, this tendency of different response time can be seen more clearly: I_{is} could not respond to the change of bias voltage, and only a slight change was observed, while I_b could follow the bias voltage change. A further detailed measurement of I_b showed the fast peak with less than ~ μs followed by a fast decay into the steady state within a few μs during the transition from state I to state II. The transition time of different parameters with dynamic bias change has a same tendency as the one in the self-excited transition case, which was obtained before.

In conclusion, we have investigated the detailed spatio-temporal characteristics of density transitions (bistable sytstem) by pulsed voltage biasing. Obtained results suggest that the plasma parameters near the electrode play an important role on the transition. These understandings will be expected to contribute to the plasma confinement and stability control.

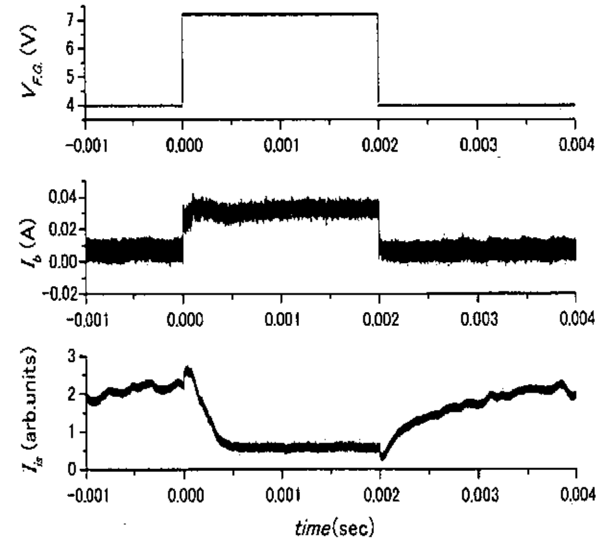

Fig. 1. Time evolutions of function voltage, bias current and ion saturation current by pulsed biasing (2 ms pulse width).

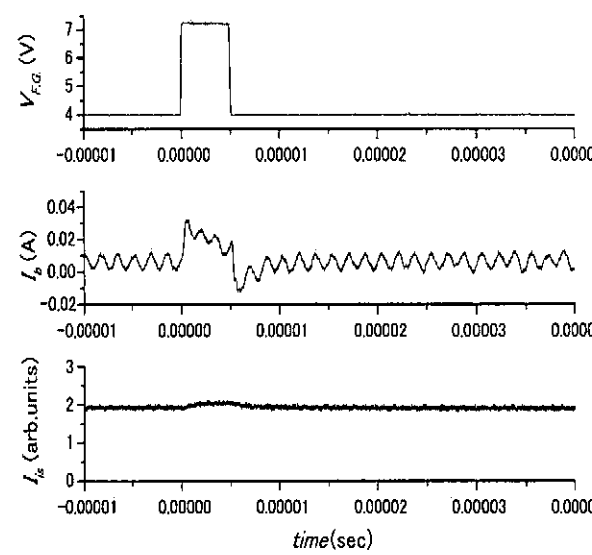

Fig. 2. Time evolutions of function voltage, bias current and ion saturation current by pulsed biasing (5 μs pulse width).

References

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