§8. Development of High Power Multi-Antenna rf Ion Source

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1, Multi-antenna ion source

We have been developing the multi-antenna rf system for large size and high power sources. The multi-antenna ion source consists of four antenna elements of 20cm long and the 35 cm x 35 cm x 21 cm rectangular source chamber. An extractor installed on the bottom of the chamber has a single hole with 5 mm in diameter. The rf power of 50kW at 9MHz and the pulse width of 10msec is connected to the antenna through the matching circuit.

2, Rf power dependence on plasma density

The dependences of plasma characteristics on rf power, Prf are shown in Fig.1, which are measured by Langmuir probe placed at the center of the chamber in the driver region. For the 2 antenna system there is a density jump around Prf~25kW and no such a jump seems to be observed on the 4 antenna system in this power range. The result from the prototype rf ion source[3] showed such a tendency that less parallel antenna number system has a small critical rf power for the density jump below 15kW. So, the plasmas for the 1-antenna and 4-antenna systems are assumed to be above and below the critical rf power region in this experimental conditions. There is no rf breakdown up to 30kW while the break down happened in the prototype antenna.

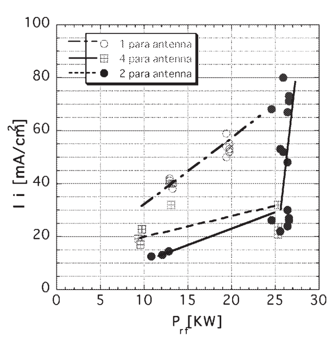

Fig.1 (a) Ii as a function of Prf for P_{H2}=6-9 mtorr for 1,2,4-antenna systems.

3, Density profile for multi-antenna system

In order to evaluate the density profile for different antenna configurations, we solve the steady state particle balance equation with the antenna and the wall boundary conditions. We assume that the plasma is produced near the antenna by the accelerated electrons and then the plasma diffuses into the chamber through mainly collision process with neutrals. We demonstrate examples in Fig.2. If the rf current ratio of 4-antennas are set as (1.3, 0.9, 0.9, 1.3) (Fig.2 (a)), the uniformity of density within 10cm long (half antenna length) in y direction become 0.03% while it is almost 5% for the equal current ratio. If the each antennas are split into three identical segments and set the rf current ratio as (1, 0.67, 1) in x direction and (1.3, 0.9, 0.9, 1.3) in y direction (Fig.2 (b)), 2 dimensionally more uniform density profile is obtained compare to the 4-antenna case. Practically, the each antenna current can be controlled by inserting the variable short inductance strip at the end of antenna outside.

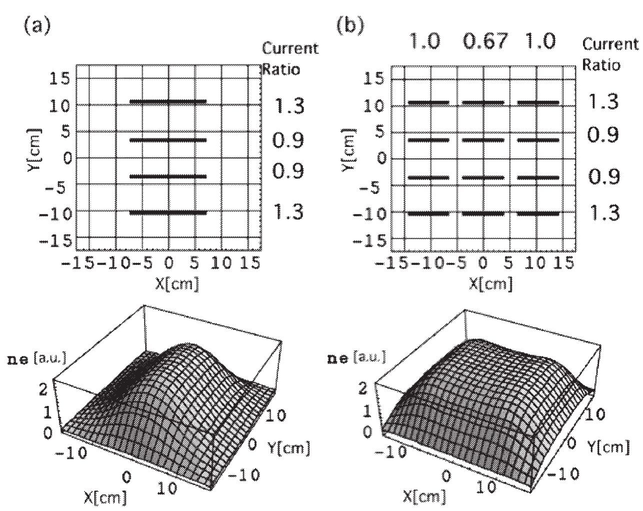

Fig.2 Density profile at z=0 for (a) the 4-antenna system with different current ratio, (1.3, 0.9, 0.9, 1.3) and (b) the 12-antenna system with the current ratio (1, 0.67, 1) in x direction and (1.3, 0.9, 0.9, 1.3) in y direction

References

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