§9. Development of Antenna System for High Power rf Ion Source

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1, Multi-antenna rf ion source

We have been developing the multi-antenna rf system for large size and high power sources[1]. The antenna consists of four parallel copper pipes (6ϕ, 20cm long) inserted into 20ϕ quartz tubes. Four antennas are installed in 35 cm x 35 cm x 21 cm rectangular plasma chamber and are connected electrically outside the chamber as shown in Fig.1. 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, Positive and negative ion beam extraction

Plasmas are produced by the inductive rf electric fields near the antenna and diffuse toward the extraction electrode. The plasma density distribution and the ion extraction depend on the antenna configurations. Therefore, the dependences of positive beam current (I_b^+) on rf power are examined for single antenna placed in different position (near the center and upper on the antenna panel). The ion current is measured by the collector current of the Faraday cup. I_b^+ for the center antenna is ~1.5 times larger than that for the upper antenna. This is roughly proportional the plasma density at the extraction hole for those 2 antenna positions predicted by the simulation [2].

Then we applied a negative voltage on the chamber and extract negative ions for 4-antenna configuration (antennas are connected electrically in parallel). The collector current (I_{CN}) is almost proportional to the extraction voltage (V_{ext}) below 2kV and tends to saturate (Prf~7kW), while the drain current to the extraction electrode (I_{HV}) is almost constant. This means the plasma density near the extraction hole does not change versus V_{ext} in this region. The negative beam current density obtained here is ~0.3mA/cm^2 but it might possibly increases when the pressure and rf power etc. are optimized.

References

1) Oka. Y, Shoji. T, et. al., Rev. Sci. Instruments, 77(2006),
2) Shoji, T, Oka, Y., Ann. Rev, NIFS, (2006) 142

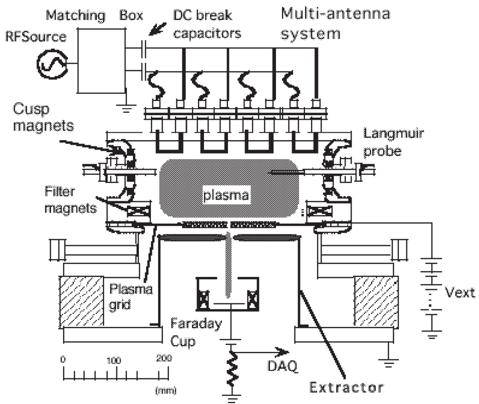

Fig. 1 4-para multi-antenna rf ion souurce

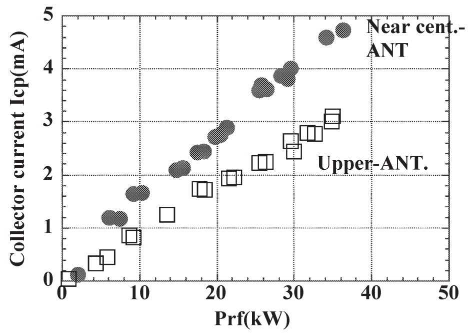

Fig. 2 Dependences of ion current on rf power for the single antenna near and far from the beam extraction hole. P_0=0.32P_a.

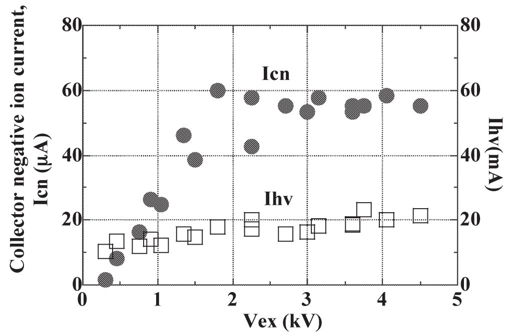

Fig.3 Negative ion current to the collector electrode of Faraday cup (I_{CN}) and drain current (I_{HV}) versus beam extraction voltage.