Plasma uniformity of a multi-hole Ar RF ion source

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1. Introduction

Ar ion source using a planar inductive coupling has been developed for an industrial application. The RF antenna is located outside of the plasma chamber. This ion source has a merit to support a large uniform ion beam. Radial profiles of plasma densities can be adjusted by the adding of the multi-polar cusp magnets.

2. Plasma profile of the RF ion source

2.1 Multicusp magnets for uniform plasma

For uniform RF inductive plasma, multipolar cusp magnets are adopted. The magnets geometry is simulated and confirmed by the poisson code [1]. A cusp magnet system is constructed with water cooling in a multipole configuration with 14 poles, and its maximum surface magnetic field is calculated to be 3.0 kG. Cusp field is increased significantly to cover whole discharge region with stronger confining field. Field null less than 30G can support around 3cm of diameter. NdFeB magnets are used to multi-cusp field.

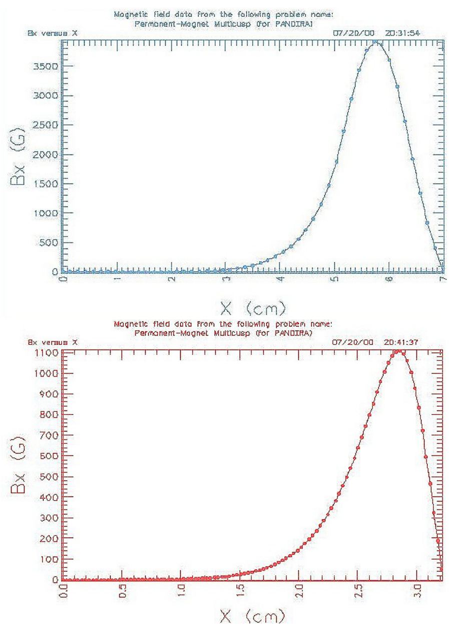

Fig. 1. Poisson calculation for multi-cusp magnets

2.2 Langmuir probe measurements[2]

Langmuir probe was used to measure a radial plasma uniformity of the ion source. The probe measures the total current to the probe. Total current is the sum from the ions and electrons. At sufficiently large negative potential all electrons is repelled from the probe and ion currents can be measured. This ion saturation current is useful for obtaining the plasma density as shown in equation (1).

$$n_e(m^{-3}) = 1.05x10^{15}\sqrt{\frac{M(amu)}{T(eV)}}\,\frac{I(amps)}{A_{prob}(m^2)} \quad (1)$$

Used probe tip size is 5mm long and 1mm diameter. As shown in figure 2, total currents were measured with the bias voltage at the center in front of the plasma electrode.

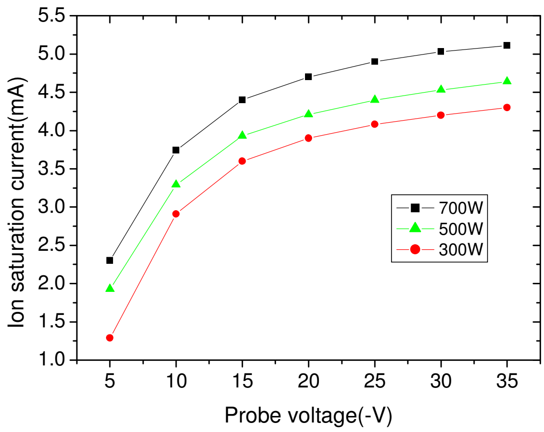

Fig. 2. Total currents measured by the probe

The current rapidly increased with a negatively voltage up to -15V and after -20V slightly increase with the voltage. Considering with an incident ion heat load, -30V was chosen for obtaining the ion saturation current. Ion saturation currents increase with RF power. From the ion saturation currents the plasma densities can be roughly estimated without the precise electron temperature information. At 5eV of electron temperature and 5mA of ion saturation current in the case of 700W of RF power, the plasma density of $9x10^{11}/cm^3$ is estimated from equation (1).

2.3 Radial plasma profile

Chamber size for plasma generation in the ion source is the inner diameter of 8cm and the length of 8cm. 10mm thick quartz window is used to support the required vacuum and sustain the plasma. The 19 extraction holes with 4mm diameter are hexagonally arrayed in 4cm diameter. O ring-sealed Langmuir probe was installed to radially scan at the extraction region.

Radial profile of the ion saturation of the probe is described in figure 3. Ion saturation currents linearly increase with RF power at 2x10-5 torr of the pressure of a beam test chamber. The currents at the center are relatively higher than those at the edge. Uniformity (standard deviation / mean) of the current is less than 10% in the 4cm diameter near the extraction hole.

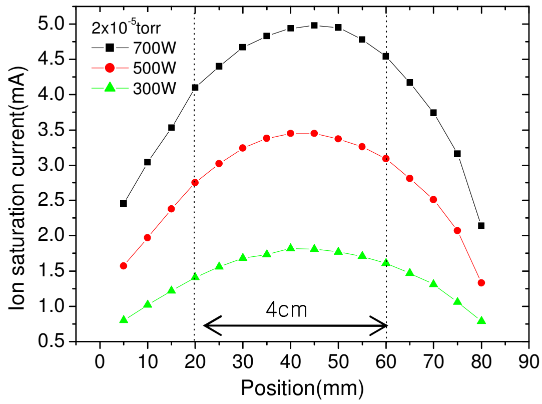

Fig. 3. Radial plasma profile measured by the probe

3. Conclusions

RF ion source was proposed and feasibility of Ar beam was tested such as multi-holes beam extraction. To check radial plasma uniformity of the RF ion source with multipolar magnets, the probe was used to measure the ion saturation current near the extraction holes. Plasma uniformity is less than 10% in the 4cm diameter. Beam profile measurement of the ion source will be tested.

ACKNOWLEDGEMENT

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REFERENCES

[1] L. Young, Poisson superfish manual, 1996.
[2] D. Ruzic, "Electric probes for low temperature plasmas" AVS monograph series, 1994