Design and construction of a multi-hole Ar RF ion source

I. S. Hong, H. S. Kim, D. I. Kim, H. J. Kwon, and Y. S. Cho
Frontier Project Proton Engineering, KAERI
**Corresponding author: ish@kaeri.re.kr*

1. Introduction

High-density plasmas generated by a planar inductive coupling have many advantageous features to be developed as ion sources for an industrial application. First of all, the rf antenna is located outside of the plasma chamber. This can reduce possible contamination from the immersed antenna and make its lifetime longer. Also, any kinds of gases including reactive gases such as oxygen can be used. Second, high density plasmas can be generated at very low gas pressures, which makes large throughputs possible by providing sufficient ions. Finally, radial profiles of plasma densities can be adjusted easily by changing the arrangement of the antenna by changing the number of antenna turns and its structure and magnetic cusp fields by changing its geometry. RF ion source has developed for an Ar ion beam using planar inductive coupled plasma.

2. Design and construction to the RF ion source

2.1 Ar ions extraction simulation using IGUN

For 20keV Ar ion beam, triode extraction system with multi holes is adopted. Beam extraction geometry is simulated and confirmed by the IGUN code [1]. Triode extraction system is composed of the plasma electrode, extraction electrode, and ground. The inner diameter of holes of the plasma electrode, the extraction electrode, and the ground is 4mm, 5mm, and 5mm respectively. The simulated beam sizes with this extraction geometry in variance with assumed Ar plasma densities can support beam currents of up to 2 mA at an extraction voltage of 20 kV as shown in Fig. 1. Plasma density for 2mA of Ar ion current is needed to higher than 5 x 10^{11} / cm^3.

2.2 Design and construction of Ar RF ion source

A schematic diagram of the RF ion source with triode extraction system is shown in Fig. 2. A cusp magnet system is constructed with water cooling in a multipole configuration with 14 poles, and its maximum surface magnetic field is measured to be 3.0 kG. Coverage of cusp field is increased significantly to cover whole discharge region with stronger confining field. Field null can support more 5cm of diameter. NdFeB is used to multi cusp field. Chamber size for plasma generation 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.

Triode system has been constructed with the dimension based on the IGUN results. The extraction holes whose has the number of 19 are hexagonally arrayed. While the plasma electrode is made on a stainless steel to reduce RF plasma sputtering, the extraction electrode and the ground on oxygen free copper. Teflon supports a 20kV high voltage insulation between the plasma electrode and the ground. For a bias insulation an alumina is used to protect thermal load.

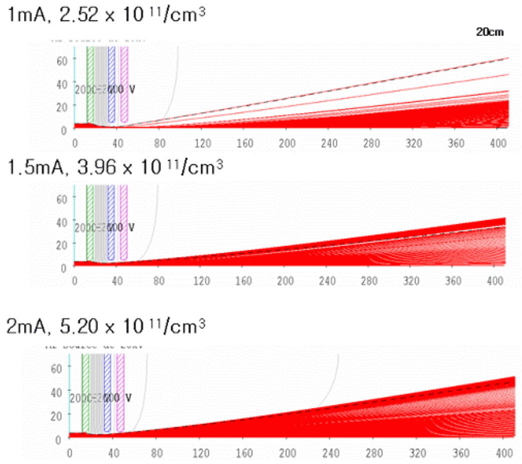

Fig. 1. Beam size at 20cm from extraction in variance with extraction currents

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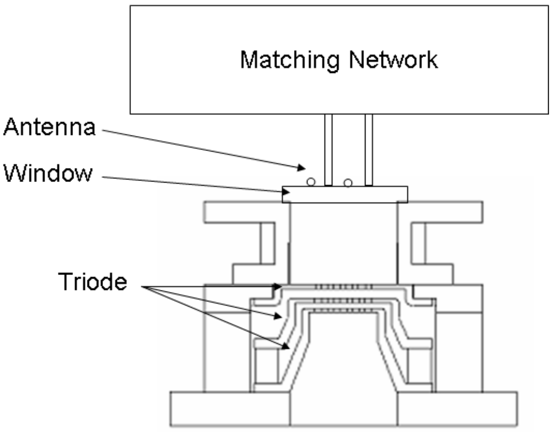

Fig. 2. A schematic diagram of the RF ion source.

13.56MHz, 1kW RF source and its impedance matching system to deliver the Ar inductive plasma has been constructed. 2 turn pan cake antenna is used to supply RF into the plasma. The antenna is constructed with a copper tube of 6mm in diameter which can support sufficient water cooling. Alternate L network using an inductive antenna is constructed to match the impedance between RF source and the plasma. This network is used two variable vacuum capacitors to compensate with inductance of the antenna and match impedance with the plasma.

RF system including the antenna is on the ground not a high voltage terminal. Ground level operation can protect the RF source a failure from a high voltage arc.

For the EMI noise protection of the high voltage power supplies of the extraction and the bias, RF choke has been installed at the output of the power supplies using high voltage capacitors and resisters.

2.3 Preliminary tests of the Ar inductive plasma

For Ar plasma ignition at around 200W of the RF power a relatively high pressure is needed to mm torr at the region of the main vacuum not the plasma chamber in the ion source. After the ignition Ar plasma can be sustained to a low working pressure of 3×10^{-5} torr for the ion extraction. High density plasma can be generated and sustained at 800W of the RF power.

3. Conclusions

RF ion source has developed for an Ar ion beam using a planar inductive coupled plasma. Reliable operation test for the plasma has been performed. We are checking the window coating and the impedance mismatch from a variance of a cooling temperature Than beam extraction from the plasma will be tested soon.

ACKNOWLEDGEMENT

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REFERENCES

[1] R. Becker and W. B. Herrmannsfeldt, Rev. Sci. Instrum. Vol. 63, p. 2756 1992.