A Compact Proton Source for Space Simulation

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Abstract A compact proton beam source for space simulation has been developed. A compact structure was designed in order to meet the special requirements of miniaturization. Some particular means have been adopted for improving the proton portion and beam transmission at a long distance. The experimental results showed that 8mA/30keV proton beam can be successfully obtained from this source at about 700W input microwave power.

Key words proton source, microwave

1 Introduction

Material property changes after radiation by electron, proton, plasma, X-ray and so on become a very important topic recently. Being a material research base, Space Tribology Center, State Key Laboratory of Solid Lubrication, Chinese Academy of Sciences is equipped with those radiation sources. As proton source, a small ECR source has been prepared for its reliability and the longevity.

2 Structural design

Figure 1 shows the source body design. For the required beam is not high, a small plasma chamber is used. Its inner diameter is Ø36mm. Meanwhile the chamber length ranges from 40 to 45mm. We expect a higher plasma density with smaller chamber when limited microwave power launched. The chamber wall is water-cooled. Its inner surface is covered with a quartz sleeve. The plasma electrode hole is Ø3mm. A three-electrode system is used. The suppressor electrode can prevent the secondary electrons at extraction region from flying back into the source.

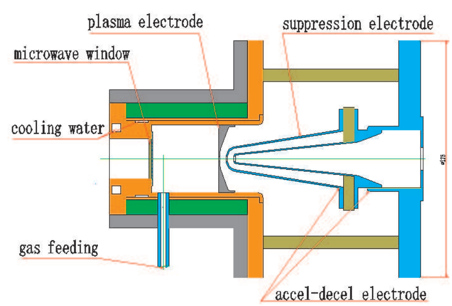

Fig. 1. Schematic plot of the proton source.

The microwave window is an alumina disk of 1.5mm thick. A BN plate is set in front of the window to remove the heat from plasma and backward electron bombardment.

The magnetic field is an important item of the source design. Many authors[1, 2] have detailed descriptions on the field configuration. In our case both

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87.5mT and 93mT resonance field are used. The 87.5mT resonance points are located near the microwave window and the extraction hole. The magnetic field distribution along the source axis is showed in Fig. 2.

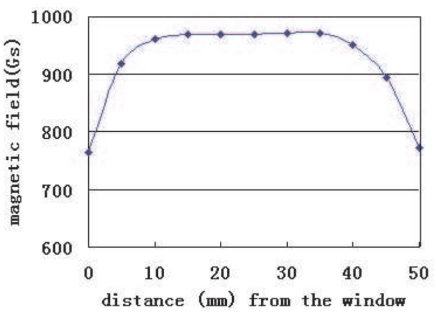

Fig. 2. Magnetic field distribution along the source axis.

3 Microwave system

The microwave feeding system is shown in Fig. 3. The magnetron is fixed onto a piece of BJ32 waveguide. The waveguide is connected on one of its terminals with a piston as a microwave tuner and on the other terminal with a ridge waveguide, on which there are three stubs settled as another means for microwave transmission and coupling tuning. The ridge waveguide is a three-section straight double- ridge waveguide. Each section has the length of quarter wavelength. The impedance of each section is decreased gradually from the BJ32 waveguide to the source window. To get a good match, the impedance of each section Z should equals to $(Z_1{*}Z_2)^{1/2}$. Z_1, Z_2 is the impedance of its adjacent sections, respectively.

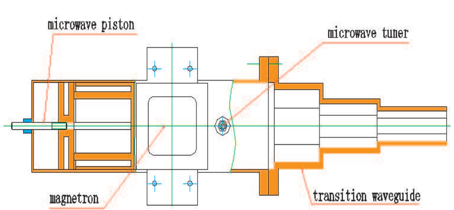

Fig. 3. Schematic plot of the microwave feeding elements.

The power supply of the magnetron is similar to that of the family microwave oven. The maximum output power of the magnetron is about 700W. At this output level, the microwave output waveform is still a pulse mode with a pulse frequency of 50Hz. At the same average microwave power, this pulse waveform output would give rise to a higher proton portion among H^+, H_2^+, H_3^+ ions inside the total beam current.

4 Preliminary test results

In order to get the necessary information on beam transmission, two Faraday cups are used. The first cup is located at 25cm away from the extraction hole. Usually it can accept almost all the extracted beam. There is almost no interception on the negative electrode. The maximum total extracted beam is about 8mA at the moment.

The second Faraday cup is 48cm away from the extraction hole. The beam current I_2 accepted by the second Faraday cup is much more dependent on the positions of the plasma electrode and the extraction electrode. At the best condition the second Faraday cup can receive about 60% — 70% of the total extracted beam. Fig. 4 shows the relation between I_2 and extraction voltage.

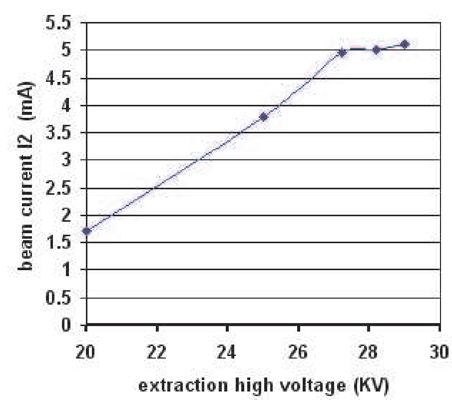

Fig. 4. Beam current on the second Faraday cup vs. extraction HV.

The saturation of beam current I_2 at high voltage 27kV is mainly due to the limited available microwave power. It is fixed at magnetron anode current of 225mA (about 630 watts power level) in this measurement. The gas flow rate is 1.2SCCM. The lower gas flow rate is favorable for getting a higher proton portion.

5 Conclusion

A very compact all permanent magnet microwave ion source has been successfully developed in IMP. The main goal of this source is to produce intense proton beam for material ion beam irradiation research. The source has been ignited and up to 8mA mixed hydrogen ion beam has been extracted though a Ø3mm aperture plasma electrode. The preliminary test shows that this source is reliable and stable.

The test is still under way. And the proton source has been mounted on the experimental facility recently. There is a powerful pumping set. We try to use plasma electrode with a little larger extraction hole in order to get more beam current. Besides, we plan to test the source to achieve more useful beam on the sample radiation board.

References

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