Characteristics of a High Current Helicon Ion Source With High Monatomic Fraction

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1. Introduction

Applications of neutron need compact and high yield neutron sources as well as very intense neutron sources from giant devices such as accelerators [1]. Ion source based neutron sources using nuclear fusion reactions such as D(d, 3He)n, D(t, 4He)n can meet the requirements. This type of neutron generators can be simply composed of an ion source and a target. High-performance neutron generators with high yield require ion sources with high beam current, high monatomic fraction and long lifetime. Helicon ion source can meet these requirements. To make high current ion source, characteristics of helicon plasma such as high plasma density can be utilized [2,3]. Moreover, efficient plasma heating with RF power lead high fraction of monatomic ion beam. Here, Characteristics of helicon plasma sources are described. Design and its performances of a helicon ion source are presented.

2. Helicon Plasma Source

To provide high density deuterium plasmas, a helicon plasma source is constructed. A quartz tube of inner diameter 22mm, outer diameter 26mm and length 150mm is used as a plasma chamber. Radio frequency power is delivered by half helical antenna at the frequency of 13.56MHz. A matching box with alternative L-type has been inserted to deliver RF power effectively. To provide axial magnetic field, two water-cooled electromagnets are installed which can provide axial magnetic fields of up to 1.5kG.

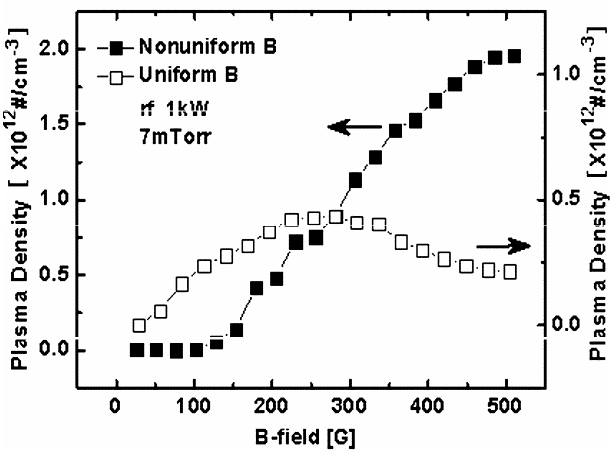

Fig. 1. Plasma densities as a function of magnetic field strength for two different magnetic field configurations

Performances of the helicon plasma source have strong dependence on the axial magnetic field. Helicon plasmas with light ions have density peaks at a low magnetic field strength. The densities of hydrogen plasmas are observed to be maximum at the magnetic field of 200G~300G in the helicon plasma source. Besides the magnetic field strength, magnetic field shape has an effect on plasma characteristics. Helicon plasmas with an asymmetric magnetic field have much higher plasma density than uniform magnetic field. In order to supply asymmetric magnetic field, only one electromagnet out of two symmetric electromagnets is turned on. Helicon plasma densities according to magnetic field strength and shape are shown in Fig. 1. Measured maximum plasma density is 2.0×10^{12} #/cm^3 at the asymmetric magnetic field of 500G with 1kW RF power. Plasma densities are measured by Langmuir probe at the position of beam extraction.

3. Helicon Ion Source

A helicon ion source was designed and constructed with the helicon plasma source. Three-electrode extraction system is installed to the one side of the discharge chamber. Turbo molecular pump of 1000*l*/s and rotary pump of 600*l*/m are equipped as a vacuum system to provide sufficient differential pumping for the ion source. An additional pumping port is placed between plasma electrode and extraction electrode to provide a better vacuum condition in the extraction region. In the case of a single aperture with 6mm diameter, it is possible to get lower downstream pressures by factor of about 60 than those of plasma generation region. Negative potential of 14% of extraction voltage is applied at a second electrode to block back-streaming electrons.

Fractions of ion beam species of helicon ion source are measured using a dipole electromagnet. In order to separate ion beams, the magnetic field of dipole electromagnet is scanned, and separated ion beams are measured by faraday cup located behind the dipole electromagnet. Fractions of ion species according to the RF power are shown in Fig. 2. The Fraction of monatomic ion beam reaches up to 94% with RF power of 1300W when ion beams are generated with uniform magnetic field of 280G at the pressure of 7mTorr.

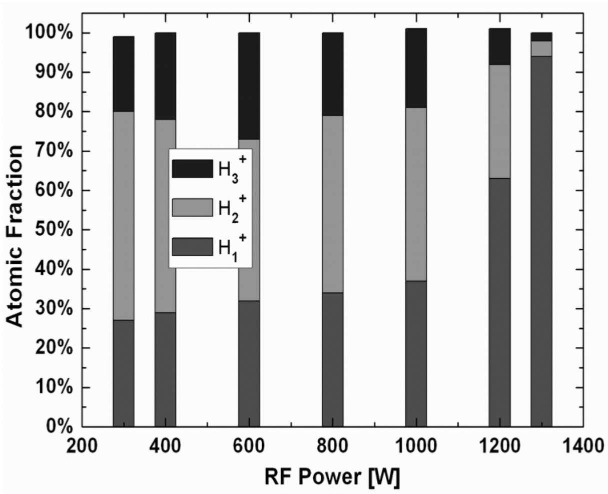

Fig. 2. Atomic fractions of ion beam for different RF powers with uniform magnetic field of 280 Gauss and neutral pressure of 7mTorr

4. Conclusion

An ion source based on helicon plasma has been developed and characterized. Hydrogen ion beams of high current are extracted from the ion source by utilizing high density helicon plasmas. High monatomic ion beam fraction of up to 94% is achieved. High monatomic ion beam fraction as well as high beam current at relatively low RF power makes it feasible to build efficient neutron generators with helicon ion sources.

ACKNOWLEDGEMENTS

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