Hydrogen Plasma Generation with 200 MHz RF Ion Source

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1. Introduction

A 1 MV Electrostatic accelerator as various ion beam irradiator is being developed at Korea Multi-purpose Accelerator Complex. The ion source for the system is required to be rugged with 2000 hours maintenance free operation time because it is installed in the vessel filled with SF6 gas at the pressure of 10 bar. A 200 MHz RF ion source is considered as an ion source. It is a simple construction and provides long life operation. The specifications of the ion source are 5 kV extraction voltage and 1 mA beam current referenced to the proton. RF ion source has been developed and undergone a performance test. Results of the test are presented.

2. Methods and Results

In this section some steps in the progress of developing 200 MHz RF ion source and of a performance test are described. The test stand of the RF ion source includes a RF system, impedance matching network, RF ion source, vacuum system, and beam diagnostic system.

2.1 Test stand of the RF ion source

A test stand of the RF ion source consists of RF system, impedance matching network, RF ion source, vacuum system, and beam diagnostic system. Its specifications are 200 MHz frequency, -5 kV extraction voltage and vacuum system consists of a 1,300-lps turbo molecular pump and a 300-lpm scroll pump.

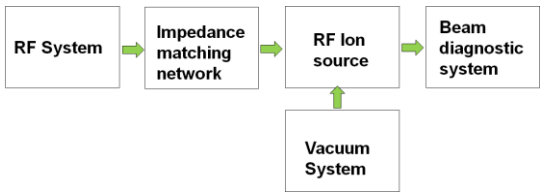

Fig. 1. A block diagram of test stand

2.2 RF system

RF system includes a signal generator, amplifier, circulator, directional coupler, and dummy load. RF power supplied by Solid State Amplifier (SSA) operating at 200 MHz. Its maximum output power is 200 W. Circulator transfers the reflected RF power to dummy load. It absorbs reflected RF power.

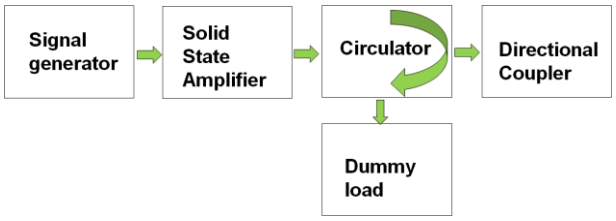

Fig. 2. A block diagram of RF system

2.3 Inductive coupling

For inductive coupling of 200 MHz RF power to the plasma, L-network matching circuit is used. It was illustrated in Fig. 3. Ls and Rs refer to the resistance and inductance of plasma, Cs and Cp refer to capacitors for impedance matching

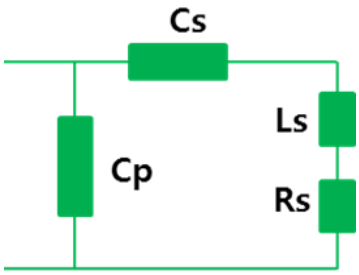

Fig. 3. L-matching circuit.

Two air variable capacitor, its capacitance covers 10 ~ 100 pF, are used in this circuit. Inductive coil is a 1-turn braided wire. This impedance matching is a tough step in developing RF ion source. Longer electrical wire has more resistance, inductance and capacitance than shorter does. We should've made single-loop compact as effectively as possible. Otherwise lots of noises appeared.

2.4 Plasma confinement

Permanent magnets are exploited for enhancement of confinement. Those are obtained by disassembling a magnetron of microwave oven. Each has maximum 0.1T strength of magnetic field. Magnets are placed in the end of pyrex tube and screens electrons coming out from the tube. It is shown in Fig. 4.

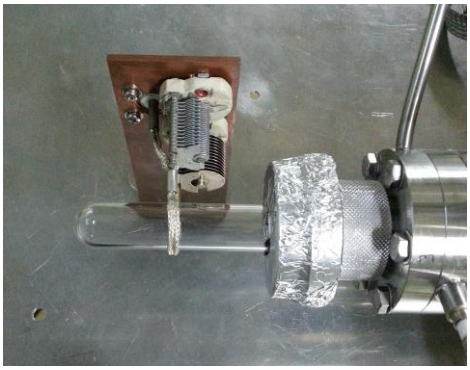

Fig. 4. Plasma confinement by permanent magnets

2.5 Operating conditions

The RF hydrogen discharge in 20-mm pyrex tube generates at pressure of 1.2E-5 torr. Net RF power is about 70 W. It has been raised up to 116 W and kept for 10 minutes. Temperature of pyrex tube has increased up to 85 centigrade. Reflected power is about 10 % of input power. In advance of the generating hydrogen plasma, the experiments using the gas of Argon had been performed. Argon plasma generates at the pressure of 5.4E-4 torr. Net RF power is about 30 W. Plasma electrode has a 4-mm diameter of extraction aperture and 2-mm distance with bias electrode. Fig. 5.shows hydrogen plasma.

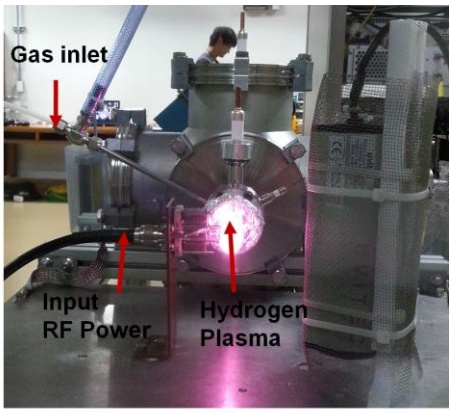

Fig. 5. Plasma with 200-MHz RF ion source

3. Conclusions

200 MHz RF ion source is designated and manufactured. First of all test stand test of ion source are set up for a performance test of ion source. It includes a RF ion source, a 200-MHz RF system, beam extraction system, vacuum system, beam extraction system, and beam diagnostic system. At pressure of 1.2E-5 torr, hydrogen plasma is generated with net RF power 70 W. Pyrex tube surrounded by an inductive coil takes the role of vessel and discharge is enhanced with field of permanent magnets.

Acknowledgement

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Reference

[1] Y. S. Cho, Basic Design Study on 1-MV Electrostatic Accelerator for ion irradiation, Transactions of the Korean Nuclear Society Spring Meeting, JeJu, Korea, 2014