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Test Bench of the Microwave Ion Source at KOMAC

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1. Introduction

A microwave ion source has been used as a proton source for a 100 MeV proton linac at Korea Multi-purpose Accelerator Complex (KOMAC). The ion source is an important part which determines the entire beam quality of the linac. A test bench was for the microwave ion source was developed to improve the performance and beam quality. In this paper, the development of the test bench and preliminary beam test results are discussed.

2. Description of the Test Bench

2.1 Microwave Ion Source at Linac

The specification of the ion source is summarized in Table 1 [1].

Table I: Specification of the Microwave Ion Source

Parameters	Values
Particle	Proton
Beam Energy	50 keV
Peak Beam Current	Max. 20 mA
Emittance	0.2 π mm mrad
Proton Fraction	> 80 %
Operation time without maintenance	> 100 hours
Microwave Frequency	2.45 GHz

The characteristic of the ion source is to use single solenoid magnet around the arc chamber to confine the plasma, which simplifies the geometry. The microwave components of the ion source are a magnetron, directional coupler, 3-stub tuner, isolation waveguide, ridge loaded waveguide and microwave window. The 1 kW, 2.45 GHz, continuous wave (CW) magnetron is used. The isolation waveguide is used to isolate the microwave components from the high voltage terminal [2]. It consists of 30 sets of aluminum plates and G-10 plates. The boron-nitride and aluminum-nitride plates are used as a microwave window. A boron-nitride lining is installed inside the arc chamber to increase the proton fraction. The extraction geometry has three extrudes, one is a plasma electrode, another is a bias electrode and the third is a ground electrode. The insulator is made of the Teflon, which has a good machinability and easy assembly but is very week against the radiation. During the pulse beam operation, the plasma is always turned on, and the extraction power supply is switched on and off by using semiconductor switches.

2.2 Improvement of the Ion Source at Test Bench

Most of the parts of the ion source at test bench are the same as the one installed at Linac. A few points are improved. The first one is the insulator of the ion source. The material of the insulator was changed from Teflon to Alumina to improve the hardness against radiation. The second one is the potential of the single solenoid magnet. An insulator was installed between the arc chamber and the solenoid magnet. Due to both isolation waveguide and insulated solenoid magnet, we could eliminate parts located in the high voltage potential and thus isolation transformer. The third one is to eliminate the boron-nitride lining in the arc chamber.

A vacuum box was installed at the downstream of the ion source, which included vacuum pumps, Faraday cup and electrostatic emittance scanner. The base pressure of the ion source was less than 1×10^{-8} Torr.

A high voltage test was carried out. A 200 kV high voltage power supply was used. The ion source withstands up to 54 kV, 10% higher than the operating voltage and there was a breakdown through the surface of the alumina insulator.

The temperature of the parts of the ion source was measured when plasma was turned on. The highest temperature was measured at the flange of the alumina insulator because the arc chamber is located inside that flange and the cooling is difficult due to the insulator of the solenoid magnet. A water cooling channel was installed around the flange to reduce the temperature from 90°C to 40 °C.

The microwave ion source at test bench is shown in Fig. 1.

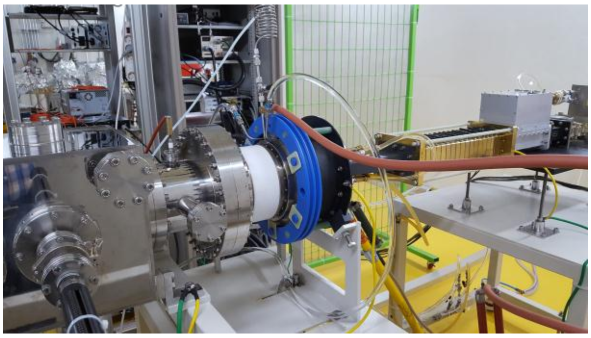

Fig. 1. Test bench of the microwave ion source.

2.3 Preliminary Test

The extraction test was carried out. The gas pressure was 1×10^{-5} Torr, microwave power was 400 W and the magnet current was 71A, which corresponds to 828

Gauss at the window. The pulse beam was extracted from the ion source by using the semiconductor switch. The pulse width was 2 ms and repetition rate was 1 Hz. The beam current was measured by using Faraday cup located at the end of the vacuum box. The peak beam current was 20 mA when we used a plasma electrode whose aperture diameter was 5 mm. The pulse beam profile is shown in Fig. 1. Beam pulse width is 2 ms with 20 mA peak current. The preliminary beam test result for 9,000 seconds is shown in Fig. 2. The beam pulse loss was 51 times for 9,000 beam pulse. The loss rate was 0.5 % and further reduced as time went by. The main location of the arc was the alumina insulator surface. The average beam current was 21.4 mA with 3.4 % standard deviation including beam loss due to arc. The beam current fluctuation is thought to be the fluctuation of the RF power from the magnetron.

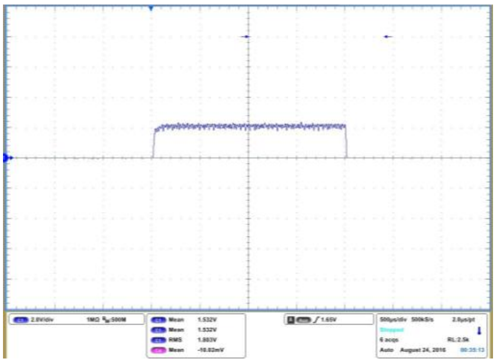

Fig. 2. Pulse beam signal: pulse width 2ms, peak beam current 20 mA.

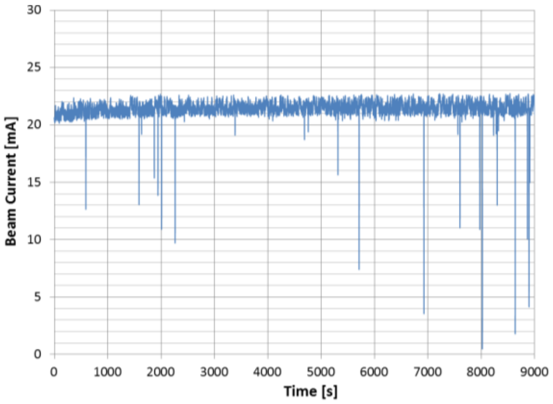

Fig. 3. Beam current for 9,000 sec.

3. Conclusions

The test bench of the microwave ion source was developed. The main improvement is the insulation between the high voltage parts of the ion source and solenoid magnet. Preliminary tests were carried out. A high voltage test showed that it could withstand up to 54 kV which has 10 % margin compared to the operating voltage. The preliminary beam test showed that the beam loss rate was 0.5 % and the standard deviation of the beam current was 3.4 %. The work is planned to check the stability of the magnetron which seems to affect the stability of the beam current. The test of the ion source will be done to measure the beam properties depending on the plasma electrode aperture and the distance between plasma electrode and bias electrode.

Acknowledgement

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