PRELIMINARY TEST OF 1 MV ELECTROSTATIC ACCELERATOR AT KOMAC

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Abstract

1 MV electrostatic accelerator is being developed to satisfy the needs from the users, especially for the applications with a MeV range ion beam implantation at Korea Multi-purpose Accelerator Complex (KOMAC). Typically, the accelerator consists of ion source, beam transport system and target chamber. For the accelerating voltage of a MeV range, ELV type high voltage power supply has been selected. And then, ion source has been selected as the newly developed RF ion source which can be installed inside the pressure vessel of high voltage power supply due to its limited space and electrical power. In this paper, preliminary test of 1MV electrostatic accelerator including test results in test stand is presented.

INTRODUCTION

KOMAC has several ion accelerators which are a 100 MeV proton linear accelerator, a 220 keV ion implanter for gaseous ion beam, a 150 keV metal ion implanter and a 20 keV high-current ion implanter and serve the beam to users [1]. In addition, some ion sources, which use the radio frequency for ignition of plasma, have been developing at KOMAC. 1 MV electrostatic accelerator with RF ion source is being developed to satisfy the needs from the users, especially for the applications with a MeV range ion beam implantation [2]. Specifications of the 1MV electrostatic accelerator are as shown in Table 1.

Table 1: Specifications

Beam Current Max.	>1mA
Operating Voltage	0.2 – 1.0MV
Energy Stability	±0.5%
Ions	Gaseous (Proton, O, N, etc.)
Power for Ion Source	<1kW
Life Time of Ion Source	>2,000 hrs

About an ion source of an accelerator, 200 MHz was selected as an operating frequency of the newly developed RF ion source. RF ion source was tested to check its characteristics in test-stand. And other components such as high voltage power supply, accelerating tube are developed [2].

In this paper, the accelerator system is generally described. And, the ion source and its test stand developments are described in following chapter. In addition, another commercial RF ion source purchased from the NEC are introduced and briefed about how to use in the future. And, the control method of the accelerator will briefly be mentioned. It replaced IDA (infrared data association) with the Fiber-optic communication to combine the other components as well as high voltage power supply based the IDA. Test results in the 300 kV test-stand are reported and its performance processes are presented.

1 MV ELECTROSTATIC ACCELERATOR

The accelerator consists of ion source, beam transport system and target chamber. The ion source and accelerating column are installed inside the pressure vessel of high voltage power supply. The layout of this system is shown in Figure 1 [2].

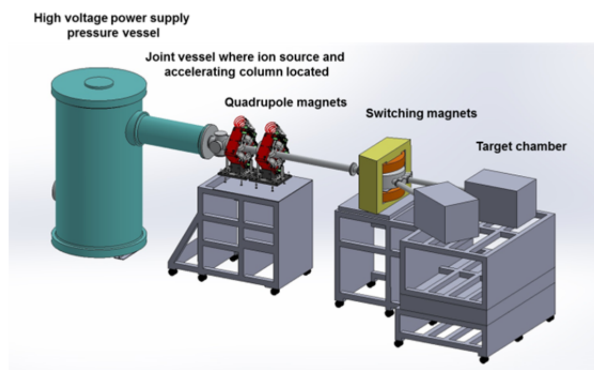

Figure 1: Layout of the 1 MV electrostatic accelerator.

Ion Source

A 200-MHz RF ion source consists of an air variable capacitor comprising a loading and tuning capacitor, a 1-turn coil, a permanent magnet, a shielding box, and an electrode. The extraction power supply on high voltage potential is manually controlled from 0 to 5 kV [3]. Figure 2 shows the operating plasma generated by its matching circuit.

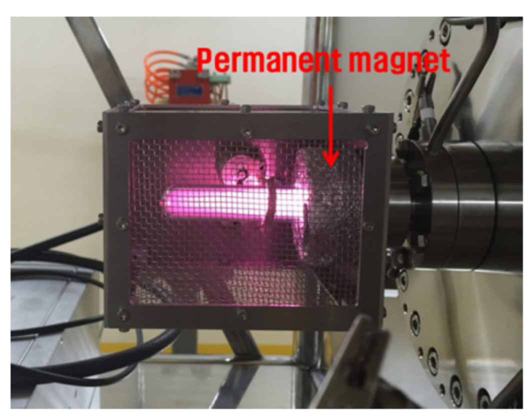

Figure 2: Plasma generated by its matching circuit.

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And, it follows the commercial RF ion source which is verified the reliability. This RF ion source has been modified by the University of Wisconsin and by NEC (National Electrostatics Corporation). This RF ion source has been used primarily to produce H+ and He+ ion beams. However, it has produced modest currents of oxygen ions, chlorine ions and other positive ion beams from gaseous elements. Figure 3 shows the extractor and RF ion source with its drawing [4]. To install it inside vessel of high voltage power supply, the shielding box should be modified to be smaller than now. And, it needs the test in 300 kV test-stand before the installation and operation inside vessel of high voltage power supply.

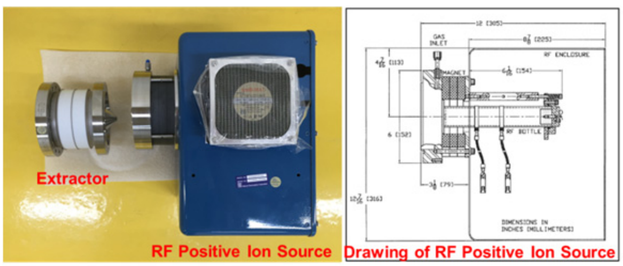

Figure 3: Extractor and RF positive ion source of left side, and drawing of RF positive ion source of right side.

Accelerating Column

It was decided to use the accelerating column which was developed for electrostatic accelerator for mine detection at Korea Atomic Energy Research Institute [5]. The column consists of two sections, twelve Al_2O_3 insulator stages per each section. The total length of one section is 250 mm long and 500 MΩ resistor is connected between electrodes and total 12 GΩ resistors are used to divide the voltage equally. The accelerating column can withstand up to 1 MV in SF_6 gas. Two quadrupole magnets are used to deliver the beam to the target chamber. The aperture diameter of the magnet is 110 mm, the field gradient is 5 T/m and the integrate field is 1 T. The switching magnet has 5 beam ports, which are ± 30°, ± 15 ° and 0° directions as shown in Figure 1 [2].

High Voltage Power Supply

The high-voltage power supply should be robust and capable for high-current operation. An inductive type power supply used for ELV (Electron accelerator originally developed by Budker Institute of Nuclear Physics, Novosibirsk, Russia) was selected [2]. It consists of 1 set of primary coil and 24 sets of secondary coils which were connected in series. The frequency of the transformer is 400 Hz and the output voltage can be changed from 200 kV to 1 MV. In addition, it has three sets of the auxiliary coils and rectifiers which produce 24 V, 500 W electrical powers for ion source operation. A sulphur-hexafluoride is used as an insulating gas with 5 bars operating pressure and all of them were installed in the pressure vessel [3]. The power supply, SF_6 gas system and 400 Hz inverters were already installed at KOMAC as shown in the Figure 4. Its test without loads like accelerating column is already done.

Figure 4: High voltage power supply.

Control for the Accelerator

The control method for high voltage power supply is the IDA but it could not be added the channels for communication due to the noise on the high voltage. To control the auxiliary components, it is chosen the fiber-optic communication to combine the other components as well as high voltage power supply. The block diagram of accelerator system is shown in the Figure 5.

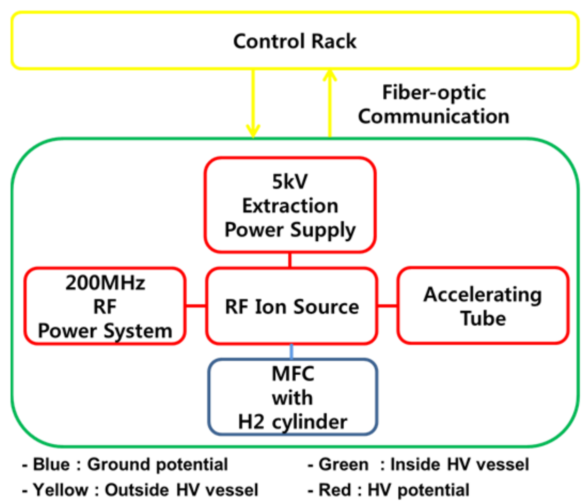

Figure 5: Block diagram of accelerator system.

300 kV Test-stand

Cockcroft-Walton which can be applied high voltage on the high voltage terminal is operated from 0 to 300 kV. 300 kV test-stand located at KOMAC site is shown in Figure 6. The test-stand consists of a 300 kV high voltage terminal, a battery of the ion source power, a 60 Hz inverter, a 200 MHz RF power, a 5 kV extraction power supply, a 300 kV accelerating tube, and a vacuum system including the beam current measurement system. In the test-stand, there is not used the isolation transformer for high voltage. An ion source and its power supplies on high voltage deck are operated by 24V batteries. When there is no test, the batteries are charged and all electrical

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powers are supplied from the batteries during test. It is advantage that the isolation transformer can be excluded [3].

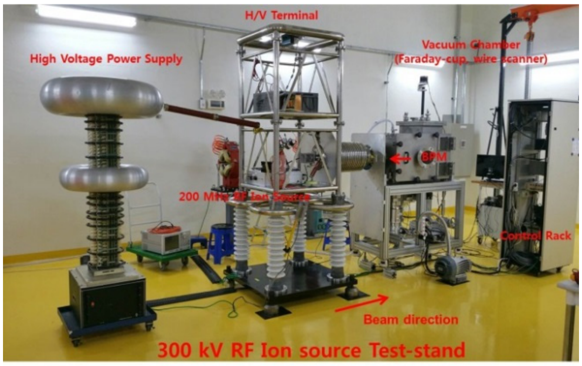

Figure 6: 300 kV RF ion source test-stand.

TEST

The beam current in 300 kV test-stand is measured by water-cooled faraday-cup at the end of chamber. The beam current was monitored by the beam monitoring system produced LabView through PLC and the current preamplifier. The beam profile monitor measured for beam shape and position was installed at the downstream from the accelerating tube [3].

Result

The result of beam current depending on hydrogen gas and extraction voltage is shown in Figure 7. A target chamber pressure was monitored to check quantity of the hydrogen gas because a mass flow controller is not installed. The beam current increases depending on the rising chamber pressure and also rising extraction voltage, and is saturated up to 600 μA above the pressure of 1E-5 Torr.

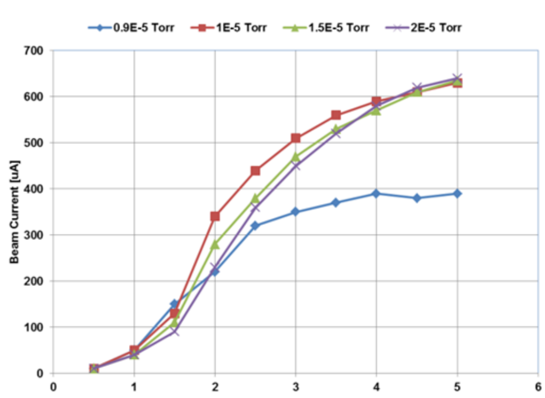

Figure 7: Beam current depending on hydrogen gas and extraction voltage.

The beam profiles were measured according to the extraction voltage and acceleration voltage. Figure 8 shows results beam size depending on the extraction voltage and acceleration voltage. The beam size increases as acceleration voltage when the extraction voltage was -1 kV. But the increasing slope is nearly constant at -2 kV and after that the beam size decreases as acceleration voltage when the extraction voltage was -3 kV. This tendency is well explained that the accelerating column acts like a lens whose power is proportional to the electric field. Also it can be explained that the matched beam is formed when the extraction voltage is -2 kV in current geometry.

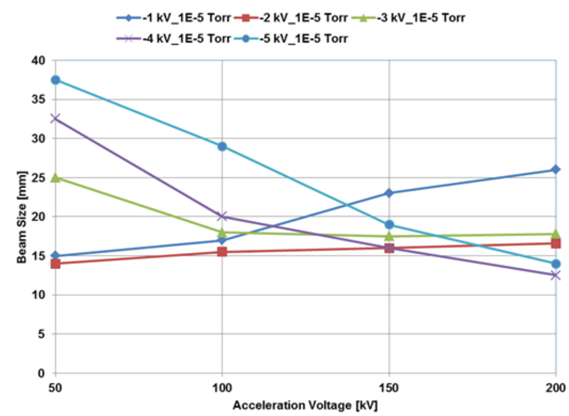

Figure 8: Beam size depending on the extraction voltage and acceleration voltage.

CONCLUSION

A 1 MV electrostatic accelerator is being developed at KOMAC. The high voltage power supply and 200 MHz RF ion source are already developed. According to the test results, it is necessary to improve the RF matching device for increasing the beam current. And, we will try to find a way to increase the beam current by using the commercial RF ion source.

ACKNOWLEDGEMENT

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