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Current status of metal ion beam accelerator and preliminary study for irradiation accuracy improvement

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1. Introduction

The KOMAC (KOrea Multipurpose Accelerator Complex) has performed beam service using proton and ion beam accelerators. Therefore many beam users required metal ions to meet their basic research and industrial application standards, but it is hard to supply metal beams. Because mainly only a few metal ions such as boron and phosphorus have been used in semi-conductor fabrication and there is no time and test facilities capable of providing beams to users at universities, industries and research institutes. KOMAC has provided the metal ions such as Cr^+, Fe^+, Co^+, and Cu^+ metal ions to users. However, there are a few problems to provide more stable ion beam and long operation time process under the current machine. Especially, beam measuring system should be modified and supplemented to improve accuracy of beam uniformity and dose rate. In this study, the current status of metal ion beam accelerator and basic study to improve irradiation accuracy, dose and beam profile, is described.

2. Current status of metal ion beam accelerator

The metal ion implanter at PEFP consisted of a bernas type ion source, analyzer magnet, slit, acceleration tube, quadrupole magnet, electrostatic scanner, faraday cup and target chamber as shown in Fig. 1 and Fig. 2. The high voltage terminal contained power supplies for ion source, ion source chamber with anaylzer magnet, mass separation magnet, slit components. The metal ions extracted from ion source were accelerated with 100keV/0.4mA (Co^+ Standard) ion energy and current at the acceleration tube. Also the desired beam shape and size adjusting electrostatic scanner and quadrupole magnet were obtained.

Fig. 1. Metal ion beam accelerator

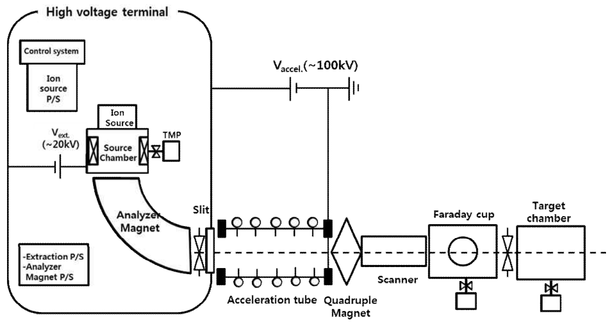

Fig. 2. The layout of metal ion beam accelerator

Table 3 shows extraction conditions of the ion source and irradiation conditions of the beam transport component for each metal ion. The accelerated voltage and current are 91 keV / 0.5 mA and the voltage of scanner is +7 kV.

Table I: Optimal process condition of ion beam

	Co^+	Fe^+	Cu^+	Cr^+
Crucible current	70A	70A	31.5A	94A
Crucible temp.	400℃	400℃	268℃	540℃
Filament current	56.5A	52A	54.7A	55A
EHC current	0.8~1.0A	0.6~0.8A	0.9~1.2A	0.9~1.2A
Arc voltage/current	150V/0.3~0.4A	150V/0.2~0.3A	150V/0.6~0.7A	120V/0.4~0.5A
Analyzer magnet current	11.9A	12.1A	9.0A	11.1A
Extraction voltage/current	9kV/5.5mA	10kV/3~4mA	9kV/12mA	9kV/2.6mA
Acceleration voltage/current	91kV/0.3~0.4mA	90kV/0.6~0.8mA	91kV/0.3~0.4mA	91kV/0.4~0.5mA
Quadruple magnet current	1.2A	1.0A	1.2A	1.2A
Scanner voltage	+7kV	+7kV	+7kV	+7kV
Scanner offset	+2.5kV	+2.5kV	+2.5kV	+2.5kV

2.1 Filament life time in ion source

Ion source life is an important component of reliability, utilization and productivity in an ion beam accelerator. During metal ion accelerator operation, a gas to be ionized is discharged into the chamber and is ionized by electrons emitted from a filament in the typical bernas ion source [1]. This type affects the life-span of the filament and indirect electron emitting method using tungsten block cathode was adopted. Thus, the filament was used to heat up the block cathode. It did not contact the plasma, so its life-span was extended. Also another important things to affect filament life time is filament feedthrough material selection because filament components are operated under 600℃. The material of filament feedthrough will alternate from STS304 to molybdenum which has lower thermal expansion

(5.43x10^{-6}/℃). Filament has been often broken at the contact area between filament and feedthrough shown as Fig. 3 and it affects operation time of accelerator.

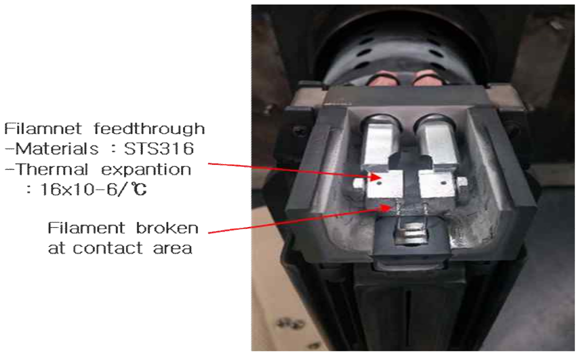

Fig. 3. Filament feedthrough of metal ion source

2.2. Beam measurement

The Faraday cup is known to be one of the most popular beam current measurement tools [2]. An electrical lead is attached, which conducts the current to a measuring instrument. To prevent secondary electron emission from the surface of the cup, electrostatic fields can be applied to the suppression ring, or a magnetic field can be applied to the surface of the cup. The faraday cup (X-axis direction) using magnetic type is installed ahead of target chamber and measured beam profile. So, it is difficult to measure exact beam size and beam profile. Fig.4 show Co^+ ion beam profile, 2.3 μ A/cm^2, at 100keV/0.4mA experiments. (Horizontal: 1s/div, Vertical: 50mV/div)

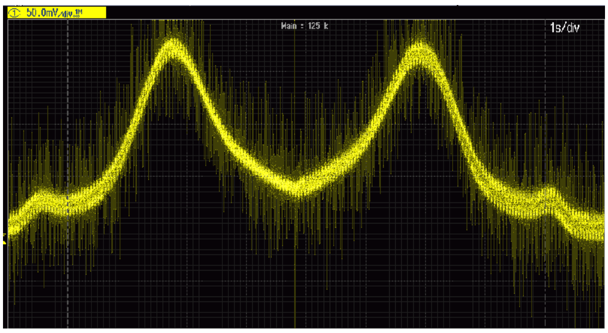

Fig. 4. The beam measurement using faraday cup

3. Basic study of irradiation accuracy improvement

3.1. Wire scanner and faraday cup supplementation for beam measurement

Beam profile measurements will be made with two wire scanners(X-Y direction) and electrostatic type faraday cup. Wire scanners obtain horizontal and vertical beam profiles and faraday cup obtain total beam current and measure dose rate. The signals from the wire and faraday cup is measured by using an electrometer and a Labview-based data acquisition system.

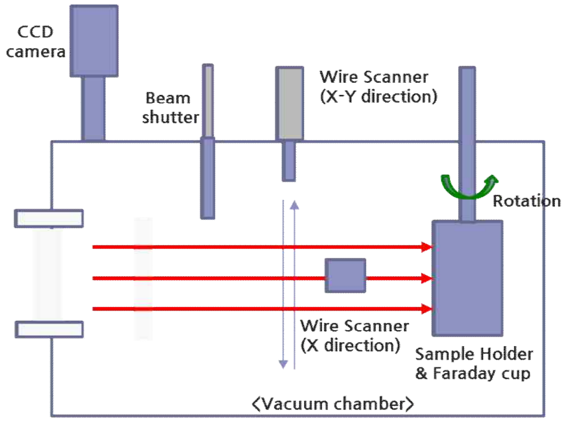

Fig. 5. Beam measurement systems in metal ion accelerator

3.2. Beam Position Monitoring with CCD camera

A beam profile monitor (BPM) using a CCD (charge coupled device) camera is non-destructive diagnostic method that gives the profile of ion beam. The position and shape of ion beam will observed by CCD camera and it is possible to check change of operation conditions.

3. Conclusions

We have successfully obtained a metal ion beam by vaporizing of various metal chlorides, Cr^+, Fe^+, Co^+, Cu^+ and the optimal extraction process conditions from the bernas type ion source. But a lots of beam measurement system requires for accurate dose. The research and development for beam uniformity should be considered and reviewed.

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