Measurement and comparison of large area beam current with the metal vapor vacuum arc ion source

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1. Introduction

The metal vapor vacuum arc (MEVVA) ion source had been installed at the Korea Multi-purpose Accelerator Complex (KOMAC). The MEVVA ion source is device that generates metal plasma and extracts ion beam using the vacuum arc discharge [1]. One of advantages is that it is can generate all metal plasma in the Periodic table. In addition, it is possible to extraction high current and large area ion beam [2]. The MEVVA ion source was designed to extract a vertical ion beam in the KOMAC. Therefore, it was installed on top of the vertical chamber. In this study, we have installed a beam profile monitor (BPM) and a Faraday cup (F/C) in order to diagnosis the ion beam. Also, we have measured the pulse of extracted ion beam. We calculated the total beam current based on the measured data, and each data was compared.

2. Experimental and Results

In this section, some method of the beam current measurement is described and results is discussed. A chromium cathode was used in order to measurement metal ion beam and the diameter of the beam is larger than 200 mm. We decided on 3 method, these are BPM, F/C and beam pulse.

2.1 Measurement of the beam current

Frist, we had fabricated the BPM for measurement of large area beam [3]. It was installed on the beam dump and can measure beam current by position. Fig. 1 shows the beam profile monitor in the vertical chamber. It is consisting of few tens' wires. The wire is alloy of tungsten-rhenium and the diameter is 100 um. The Signal wires and suppress wires are arranged on order and each signal wires are insulated. To measure the beam current, the signal wires are connected the digital current integrator and counter through the feedthrough.

Second, we had installed the faraday cup and it is placed on the sample stage in the chamber. Its diameter is 6 mm, and it is protected from ion beam by collimator. The sample stage can be moved two direction during extraction ion beam. So, we have measured the beam current by position while move the faraday cup during the ion beam extraction.

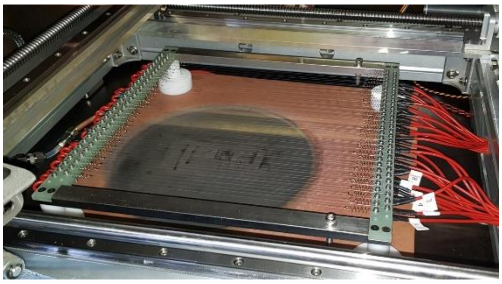

Figure 1. The beam profile monitor.

Third, the beam pulse was directly measured for each position using the BPM. In this experiment, each wire in the BPM is connected to an oscilloscope. The wires were connected to multiple relays designed to enable wire selection. Therefore, we can measure by selecting the wire current signal at the desired location. Fig.2 show the extraction voltage and beam signal during the ion beam extraction. The blue line is the extraction voltage signal using high voltage prove, and its ratio is 1:10,000 V. The red line is the beam current signal near the beam center, and it is used 1 kΩ. All current signals have a maximum value at the center, minimum value at the outside.

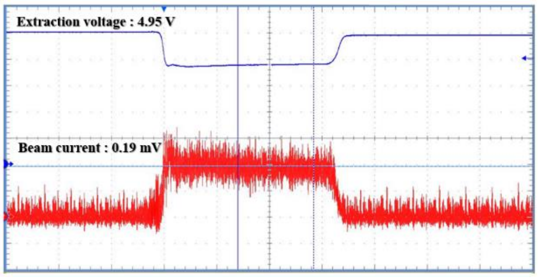

Figure 2. The results of oscilloscope.

2.2 Comparison of beam current

In this section, we had measured the beam current by above method. All experimental conditions are the same; repetition rate is 4 Hz, pulse width is 700 usec, arc voltage is 45 V and extraction voltage is 30 kV. The beam current density is measured by BPM wires arranged at sample intervals. This means the beam current density for each position of the ion beam. In addition, the beam current density data was accumulated for accurate data analysis during the experiment. Fig. 3 shows the results of the chromium ion beam current using the BPM. The current signal was measured as a coulomb by the charge integrator. The current density has the highest at the center and the lowest at the outer part. Also, the beam current density is not measured ±100mm, it is due to the collimator. The fitting curve of the beam current density is also shown in Fig. 3. The total current of ion beam was calculated based on measured current density.

$$I_{Total} = \int_{-x}^{x} J(x)\, dx \qquad (1)$$

Equation (1) is the formular to calculate the total current. J(x) is the current density each position, and the total current was calculated by integrating the section with data. The total beam current is 316.73 mA.

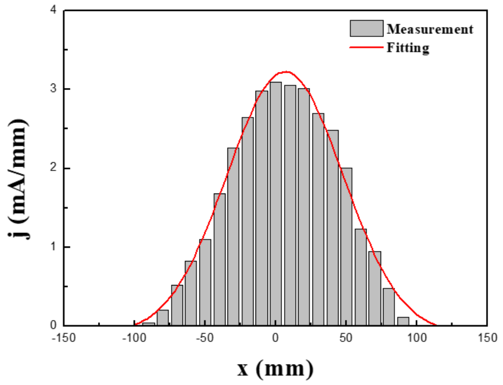

Figure. 3 Current density by the beam profile monitor.

Fig. 4 is results of the beam current density using the F/C. This was measured using sample stage while move 10 mm. And only the radius was measured. The results of the F/C have a slightly different tendency from above result. The beam current gradually decreases to 60 mm. After that, it decreases sharply. It also has a rather high beam current at the 100 mm. It is because the F/C has a rather wide diameter.

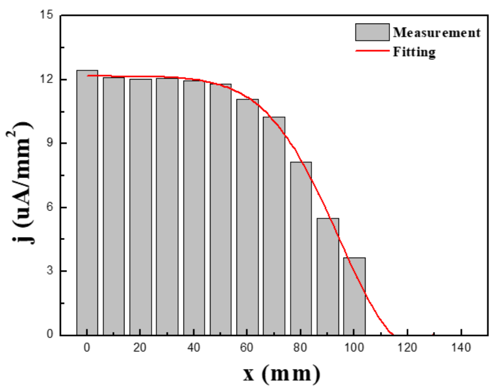

Figure. 4 Current density by the faraday cup.

In the Fig. 1, the diameter of BPM wires is 100 um and each wire is measured independently. However, the measuring diameter of the F/C is larger than wire diameter. So, the current measurement for each position is affected by surrounding current. Since this data was measured only the radius, the total current was calculated using Equation (2). And the calculated total current is 333.12 mA.

$$I_{Total} = \int_{0}^{r} J(r)\, 2\pi r\, dr \qquad (2)$$

Fig. 5 is results of the beam current density using the oscilloscope. The pulse peak was measured at each position. Also, the average value was used by measured data at 30 times or more in each channel. In this experiment, the BPM was used to measure the beam pulse signal for each position, and signal of each channel was measured by oscilloscope. The operation data of MEVVA ion source can be measured such as the extraction voltage, peak current of each position and pulse length. The pulse of each position was measured and Fig. 5 shows the current density. In this result, this includes noise level each position. Even if there is no ion beam, the signal is measured at the outside. Also, the total current was calculated from the fitting curve of Fig. 5 using Equation (1), it is 311.42 mA.

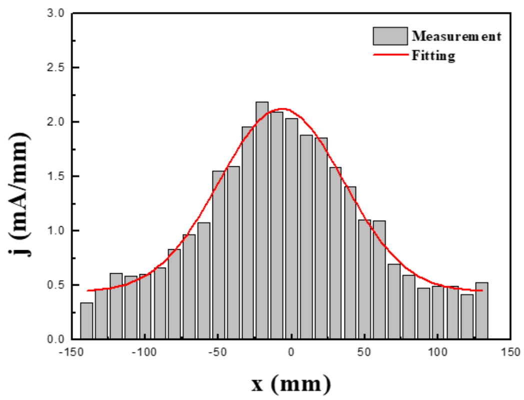

Figure. 5 Current density by the oscilloscope.

3. Conclusions

In this study, we have measured the metal ion beam current with the various method. The diameter of metal ion beam from the MEVVA ion source is about 200 mm and it has a Gaussian distribution. The total beam current is 316.73, 333.12 and 311.42 mA respectively as the BPM, faraday cup and beam pulse. These have similar values. In the future, we will measure more ion beam data from various experimental condition.

REFERENCES

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