Measurement and Comparison of Large Area Beam Current with the Metal Vapor Vacuum Arc Ion Source

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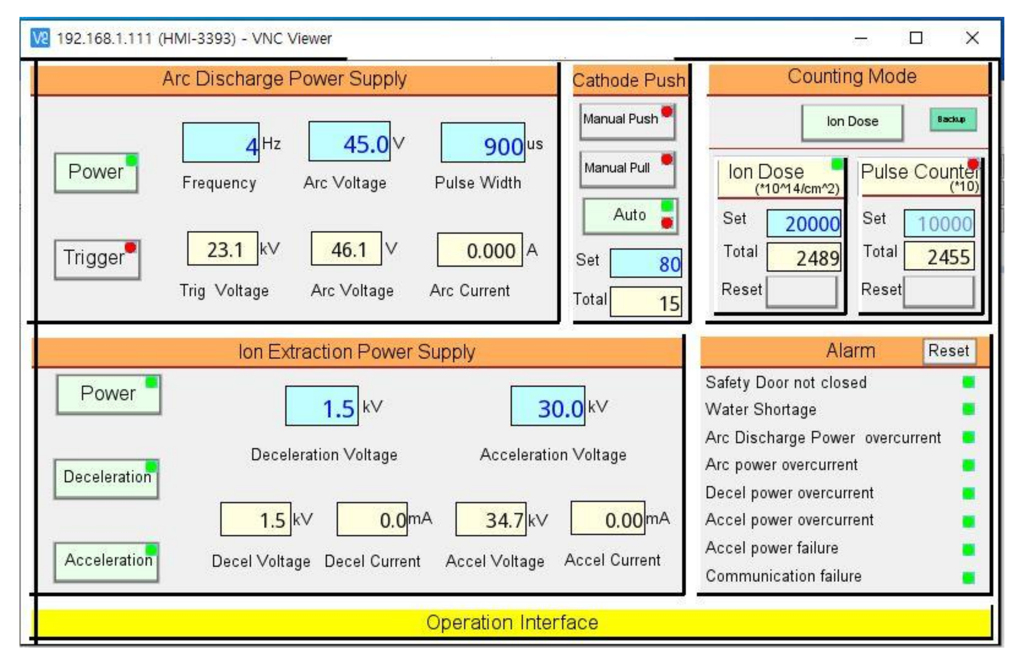
Abstract

The Metal Vapor Vacuum Arc (MEVVA) ion source has been installed at Korea Multi-purpose Accelerator Complex (KOMAC). The MEVVA ion source generates metal plasma through the vacuum arc discharge and extracts metal ion beam inside of the extraction grid. One of advantages is that it has high beam current and large area beam size. It is due to the properties of the vacuum arc discharge. The vacuum arc discharge occurs between the cathode and anode inside the MEVVA ion source. When initiation of the vacuum arc discharge, the current is concentrated on the cathode surface tiny spot, and the cathode surface is melted by concentrated arc current, therefore cathode is heated, vaporized, and ionized into the plasma state. In this phenomenon, the MEVVA ion source can generate and extract the wide metallic ion species, which is difficult with conventional metal ion source, such as the high melting temperature materials (tungsten, graphite), pure semi-conductor materials (silicon, germanium). Also, the MEVVA ion source generates metal plasma of the high multiple charge stage, and can extract the high current metal ion beam. In this study, we measured the large area metal ion beam in order to the analysis and characterize the MEVVA ion source. the beam profile monitor (BPM) and the Faraday cup (F/C) was developed to measure the metal ion beam and the beam current was validated with each measurement methods.

MEVVA Ion Source & Facility inspection

< Fig. 1 > Ion beam facility based on the MEVVA ion source

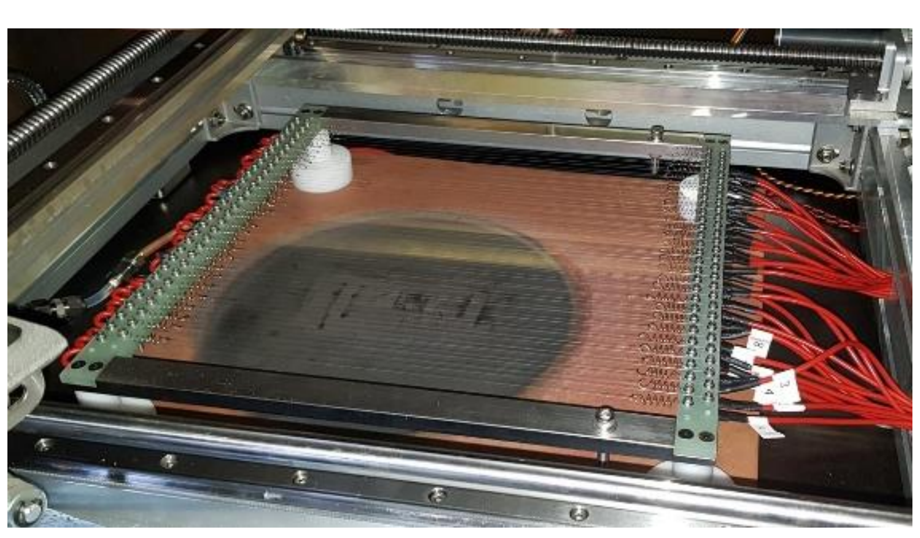
- Fig. 1 shows the ion beam facility based on the MEVVA ion source.
- There are consist of the ion beam facility (the MEVVA ion source, the irradiation chamber, vacuum system (left)) and the power supplies (right).
- The ion beam facility is configurated with vertical type. The MEVVA ion source is installed on the irradiation chamber. And the metal ion beam is extracted to sample.
- The power supplies are consist of the power of trigger, arc and high voltage.



< Fig. 2 > Control system of the MEVVA ion source

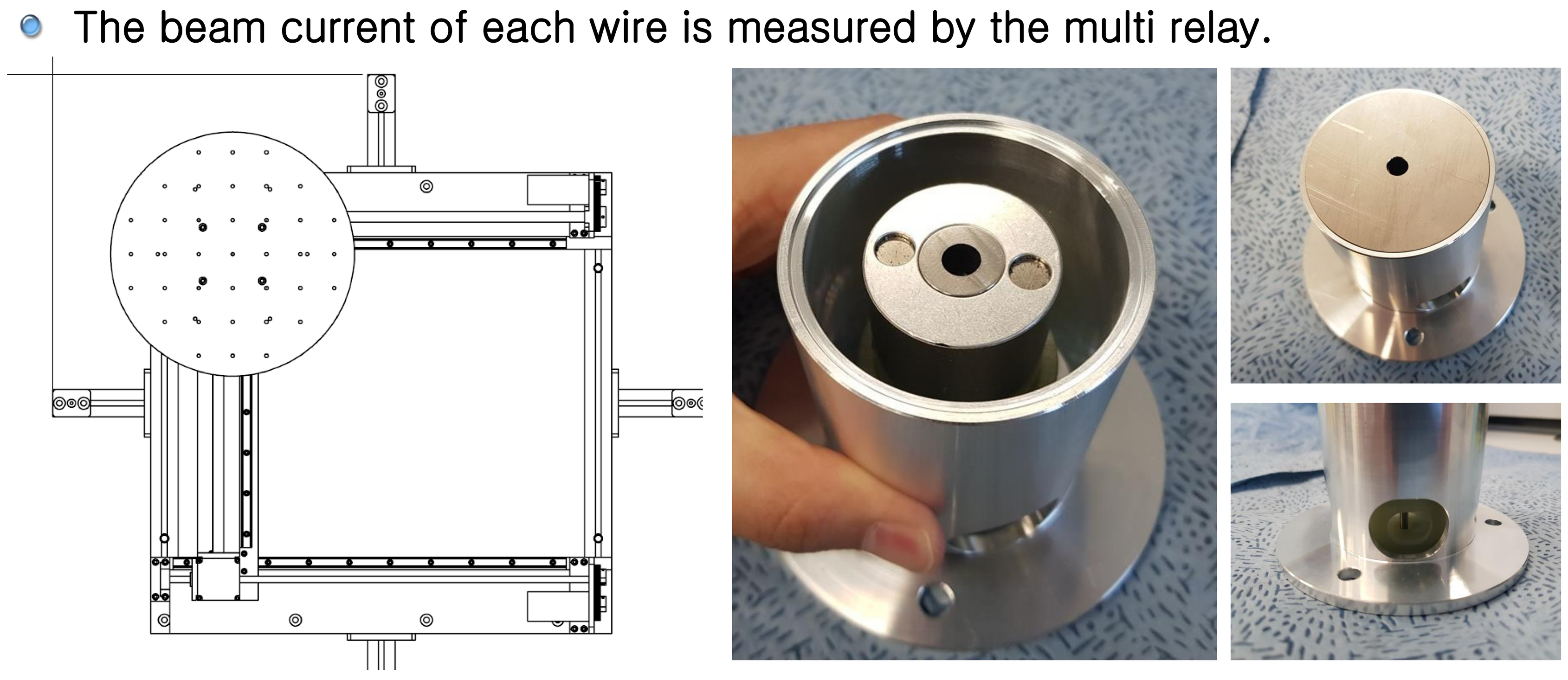
- Fig. 2 shows the control system of the MEVVA ion source.
- Arc discharge power can adjust 1-20 Hz of repetition rate, 40-100 V of arc voltage and 200-1500 μsec of pulse width.
- Ion extraction power can adjust 0-2 kV of suppressor voltage and 30-80 kV of extraction voltage.
- The cathode push compensates for the height from cathode erosion during the operation.
- And counting mode is counting ion dose and pulse count.

Experimental & Results



< Fig. 3 > Multi wire BPM

- Fig. 3 shows the multi wire BPM in the irradiation chamber.
- It was developed to measure ion beam profile. The number of wire for measurement current is 28 ea, and diameter is 0.1 mm. And it can measure 300 x 300 mm beam size.
- The material of the wire is tungsten-rhenium alloy. It has good resistance of heat and radiation.
- The wire is connected to the insulated frame (Glass Fiber, G10) by spring to prevent stretch due to the thermal expansion from beam current.
- The beam current of each wire is measured by the multi relay.

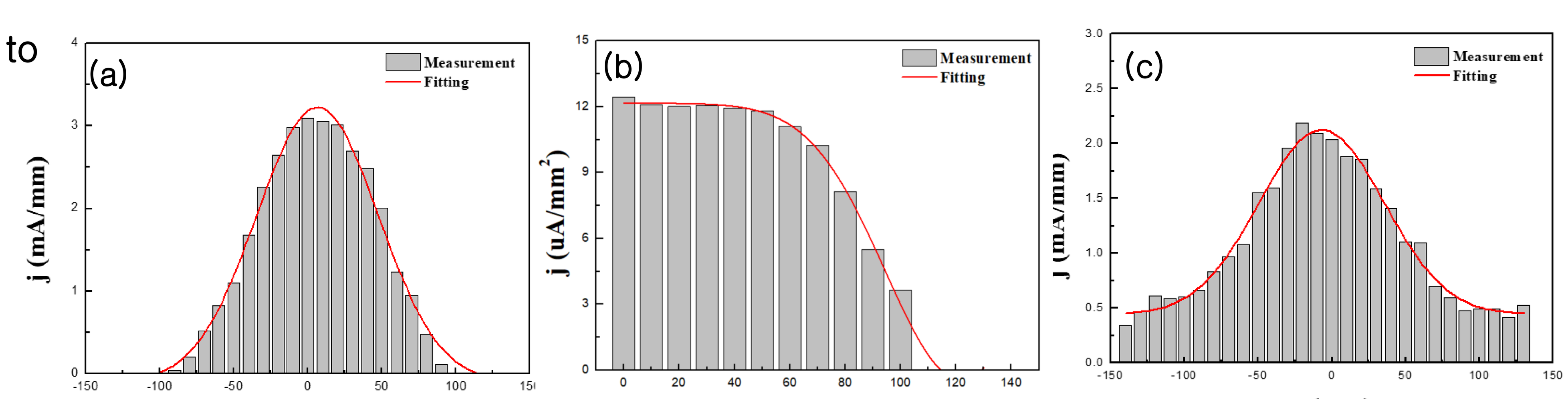


< Fig. 4 > X-Y stage and the Faraday cup

- Fig. 4 shows the X-Y stage and F/C. The X-Y table can move two axis during the operation. And the faraday cup was installed on the stage. The permanent magnet is installed at the front of the F/C. It suppresses secondary electrons and measures the current more accurately. An case was installed to protect the permanent magnet from the beam.
- The Faraday cup can be moved by the stage and can measure the beam current by position.

◀ < Fig. 5 > Current integrator and Counter

- Fig. 5 shows the current integrator (Model 439, ORTEC) and counter (Model 994, ORTEC). There is connected multi wire BPM and F/C.
- The current integrator can be connected to BPM by selecting each wire through multi relay. And the beam current can be measured at each location.
- Also, the current integrator can be connected with the F/C. The F/C can be moved by the X-Y stage, so it can measure the beam current for each location.



< Fig. 6 > Current density of beam position with (a) Multi wire BPM + current integrator (b) F/C + current integrator (c) Multi wire BPM + Oscilloscope

- Fig. 6 shows the current density of the metal ion beam with different measurement method with the multi wire BPM, F/C and the oscilloscope.
- The grey square is measurement data and the red line is fitting results. Fig .6(a) is result measured by multi wire BPM. Fig. 6(b) is result measured by the F/C using X-Y table. It was measured along the beam radius. Also Fig. 6(c) is result measured by the oscilloscope. Fig. 6(a) and (c) was measured along the axis of the ion beam, and the Fig. 6(b) was also measured along the radius.
- There results have similar trend. The current density has a maximum value near the beam center and decreases to the outside. But Fig. 6(c) has some noise.
- The total current was calculated based on the Fig. 6, and each the total current is 314.5, 347.1 and 346.1 mA

Conclusion & Future Plan

- In this study, the current of the metal ion beam was measured with the beam position. And the total current is compared with different method such as the multi wire BPM, F/C and oscilloscope.
- The total current is similar measured by different method. But, the total current of multi wire BPM is rather low. It will be verified again in the future experiment.
- In the next study, the metal ion beam dos will be measured using the ion beam current and charge distribution results.

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