The Study of a Beam Profile Monitor based on Faraday Cup Array

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1. Introduction

Faraday cup (FC) is a metal cup or plate designed to catch charged particles in accelerator and ion implanter with vacuum and it is the simplest and oldest of ion detectors, which has advantages following; extremely high robustness, reliability, long-term stability, and measurement of absolute ion currents with high linearity over a wide dynamic range[1]. When a beam or packet of ions hits the metal cup or plate, it obtains a small net charge while the ions are neutralized. The metal can then be discharged to measure a small current equivalent to the number of impinging ions. The beam current can be measured and used to determine the number of ions or electrons hitting the cup. Recently, beam profile monitor (BPM) based on Faraday cup array (FCA), which represented beam position through the spatial and temporal distribution of the beam current, has been studied due to advantages of measure of wide-range ion beam current [1-3]. FCA system is divided into a FC, an electrical circuit and display parts.

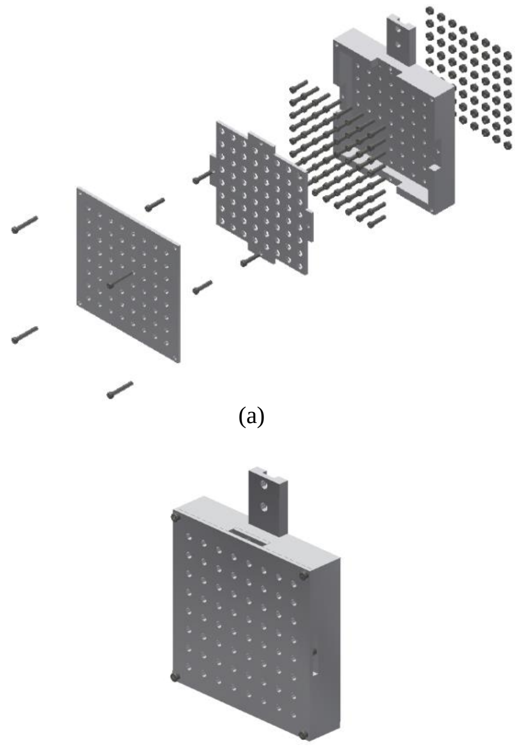
We have studied FCA to monitor beam profile on an electrostatic accelerator with wide-range ion current. In this paper, we represented basic characteristics and designs for the fabricated FCA.

2. Fabrication of FCA system

The FCA system consisted of FC, printed circuit board (PCB) based on multiplexers, and display parts.

2.1 Design of FC system

Fig.1 (a) represented assembling process of FC system and (b) shows the completed FC system, and the structure of FC system arranged in a collimator, a suppressor, tiny FCs, and an insulator frame connected with tiny FCs and PCB. 64 tiny FCs arranged into an array of 8 rows and 8 columns and overall size of FC system was 80 × 80 mm^2. Collimator played the role of protection for the suppressor from ion beam and led the ion beam to FCs. The suppressor suppressed to emerge secondary electrons through giving bias. FC was designed with diameters of 4 mm and the tiny FCs was built like bolts and nuts. The collimator, suppressor, and FCs were made of aluminum (Al) and the insulator frame was considered to use epoxy fiber glass material (G10). The PCB was considered to connect to insulator frame backside and FCs fixed insulator frame and PCB by using FCs. It is not easy to extract 64 signal lines out of chamber and hence, the electronic readout system consisted of multiplexers and binary counters set up to backside of FC system to reduce the number of the signal lines.



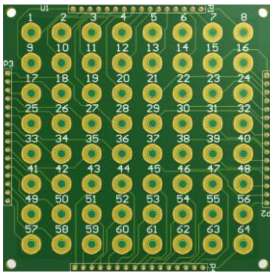
(a)

(b)

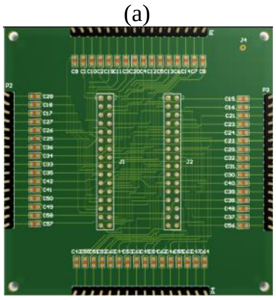
Fig. 1. schematic diagram of FC system: (a) tilted view for assembling process of FC system, and (b) tilted view of completed FC system.

2.2 Electrical circuit and design of PCB

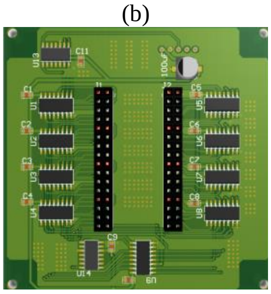
8 × 8 FC system needed to extract 64 signal lines out of vacuum chamber and it meant not to obtain high vacuum in chamber due to 64 feed-through. To deal with signal process efficiently and obtain high vacuum, electrical circuit with multiplexers was suggested. Fig.2 (a), (b), and (c) represented the fabricated PCB: electrode PCB (elec PCB), capacitor PCB (cap PCB), and control PCB (con PCB), and those were completed by assembling with board to board connectors. The elec PCB connected to tiny FCs and transmitted beam current to cap PCB, which was connected with con PCB. The cap PCB installed 64 capacitors and a FC was linked to a capacitor in sequence. The con PCB consisted of 9 multiplexers and 2 binary counters and it processed the output current for ion beam.



(a)



(b)



(c)

Fig. 2. The fabricated PCB: (a) elec PCB, (b) cap PCB, and (c) con PCB

2.3 FCA system set-up and experiment

The FCA system was applied to the electrostatic accelerator. It was installed in vacuum chamber of electrostatic accelerator and five signal lines, which consisted of V_{cc}, ground, pulse counter, enable (EN), and output, were only employed to extract the output from vacuum chamber. However, an integrator was set-up out of vacuum chamber to alter its capacitor, efficiently. The output was displayed with LABVIEW program.

3. Results

The output of FCA system fed an integrator positioned out of chamber and its results represented BPM. The system was operated by PXI with LABVIEW program consisted of two counters and one analog input. When the experimental condition was 1 nF capacitors in cap PCB, V_{cc} of 5 V, S1 of 70 ms, S2 of 30 ms, initial delay of 30 ms, and measurement frequency of 10 kHz, the BPM result for electrostatic accelerator represented ellipse shape as shown in Fig.3. The peak of beam intensity was shown at the center of BPM. It was considered that FCA system needed to increase its size and to have delay time between multiplexer operations in FCA system due to signal noise in order to monitor more correct beam profile.

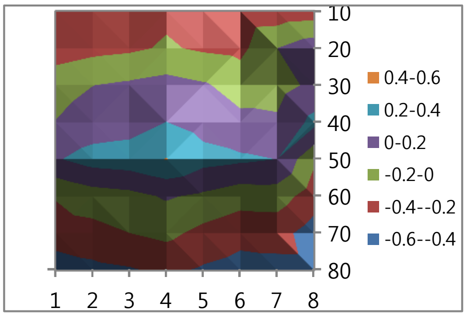


Fig. 3. BPM for electrostatic accelerator.

4. Conclusions

FCA system, which consisted of FC system, electronic readout system, and output display, was suggested to measure ion beam current, efficiently. FC system consisted of a collimator, suppressor, tiny FC, insulator frame, and circuit board divided into elec PCB, cap PCB, and con PCB. FC size was 4 mm diameters and FCA system was considered as 8 $\times$ 8 array and whole size of 8 $\times$ 8 mm^2. FCA system was set-up in vacuum chamber and an integrator and output display parts were formed out of chamber to minimize number of feed-through. As the result of BPM for electrostatic accelerator, the ellipse shape was obtained.

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