The characterization of beam profile by modification of electrode shape

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1. Introduction

Ion sources have been used for variety of industrial application over the past few decades and our research group has been studied about high current and large dimension ion source to meet the requirement from beam user.

For a mass production in industry, a wide beam divergence and a beam profile of a broadly Gaussian shape is very needed. Generally, the production process like roll-to-roll or in-line system is need one-meter in diameter, ±5% in uniformity. Therefore it is difficult to apply with present system like 0.3-meter in diameter, ±20% in uniformity and needed new type ion source.

In this study, it is approached with modification of electrode grid shape without fabrication of new type ion source. We modified from parallel type to hemispherical type electrode grid to secure large dimension ion beam and were discussed with respect to beam profile calculated with IGUN code simulation. Also, we identified beam profile before and after modification of electrode grid system(cathode, Acell-decel grid) with measurement of faraday cup.

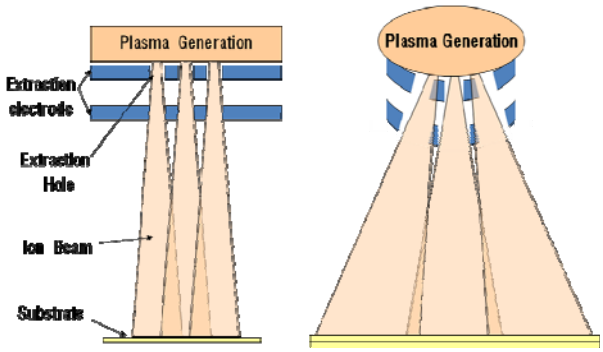
2. Methods and Results

2.1 DuoPIGatron Ion Source

The duoPIGatron[1] ion source has three electrodes such as cathode, intermediate electrode, and anode. It is designed to extract 50mA current at beam energies above 40 keV and composed of accel-decel grid structure. These electrodes are water cooled to minimize heat damage. An ion beam where all of the apertures in the grids are arranged parallel, produces parallel beamlets with beam size of 200mm-diameter . But, it is not possible for such a beam to provide a uniform flux profile over a target diameter as large as 200mm, because points at the edge of the target will clearly be struck by flux from fewer beamlets than points at the center of the target. The beam extraction geometry is simulated and confirmed by the IGUN[2] code.

2.2 The design and fabrication of electrode grid system

Broad-beam gridded ion sources are in use with ion optics consisting of one, two, or three grids. All of the gridded ion sources described below can use two grids as shown in Fig.1. We modified shape of extraction system, cathode, Accel and decel grid from parallel type to hemispherical type. The Fig. 1 shown beam size is increased significantly after modification although the limit of geometry. Beam extraction geometry is simulated and confirmed by the IGUN code and simulated beam profiles with this extraction geometry shown in Fig. 1 provide beam currents of 10 mA at an extraction voltage of 50 kV.



(a) Before (b) after

Fig. 1. The concepts of electrode grid system

A high current ion source which is capable of uniform irradiation over a large area by using a beam extraction system which extracts ion beams through multiple beam extraction holes whose central axes make successively diverging angles of about 60 degree from the axis of the hemispherical extraction electrode.

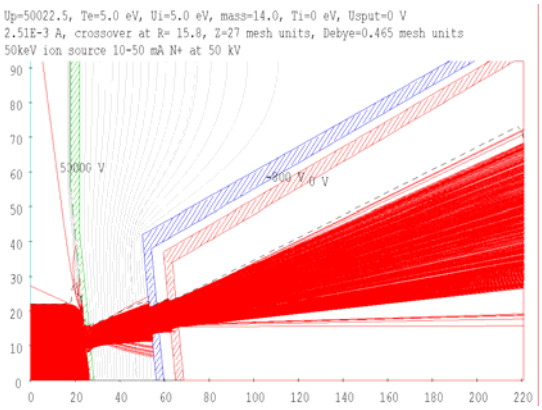


Fig. 2. Nitrogen beam profiles from IGUN simulation at 50kV / 10mA.

We designed and fabricated the cathode and Acell-Decel grids of a hemispherical type which is 10° angle in the horizontal-axis with based on the IGUN code simulation results. The grid hole size and number are 8mm-diameter and 4 hole considering beam optics and

the design is shown Fig. 3. The design of electrode grid system is shown the red line is modified grid.

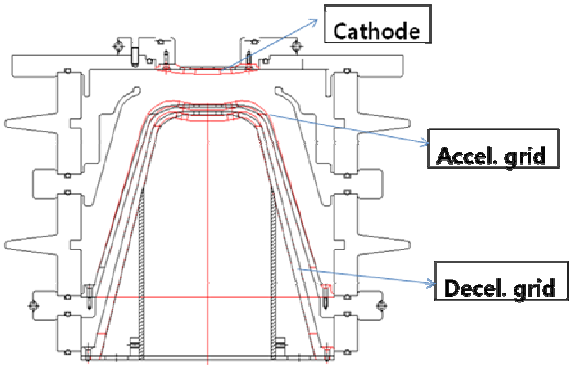


Figure 3. The design of electrode grid system

2.3 The characterization of ion beam profile

The suppression of secondary electrons which are produced during the ion bombardment can be accomplished most simply by using a negatively-charged electrode(suppression electrode) mounted in front of the sample holder. So, We measured ion beam profile to identify difference of parallel and hemispherical grid with faraday cup[3] approved bias voltage -350V. Its parts are composed tantalum and ceramic material due to heat damage by high power.

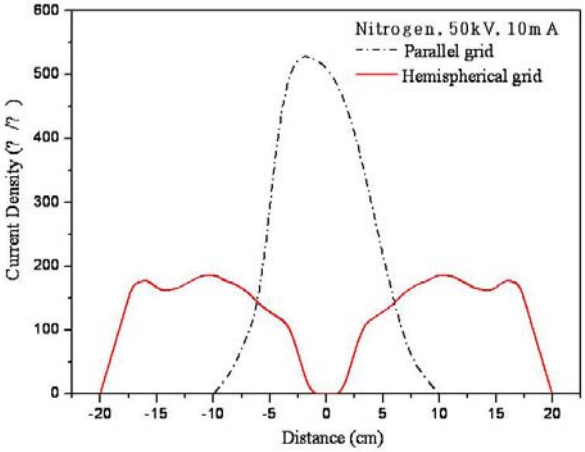


Fig. 4. The beam profile with faraday cup

We measured nitrogen ion beam profile with 50kV energy and 10mA current in comparison before and after modification and show the Fig. 4. It is shown the difference between parallel grid and hemispherical grid significantly. In case of parallel grid, the current density(530μA/cm^2) is very high, and beam was focused at center with beam size of 200mm-diameter by affected beam optics compared to low density(190μA/cm^2) of hemispherical grid which has broad beam shape and large dimension with about 400mnm-diameter. However, the center of beam is not uniform because of beam optics. We may acquire more data results with increasing energy and current in the future experiment although it is not good uniformity now.

3. Conclusions

We designed and fabricated electrode grid system of DuoPIGatron ion source which is modified with hemispherical grid to meet mass production in industry. Before fabrication of grid, we could find that divergence rate of beam with IGUN code Simulation and fabricate electrode grid system based on it. We measured beam profile before and after modification and identified hemispherical grid plays a huge role in broad beam. In the future experiment, we will measure the beam profile with increasing ion energy and current.

4. Acknowledgement

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