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# Measurements of Ion Beam Current at a Self-Focusing State in High-Current-Density and Low-Energy Ion Beam Using the Concave shape of Electrodes

凹型電極によって引き出された低エネルギー高電流密度イオンビームの自己集束時における静電ダブルプローブによるイオンビーム電流計測

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A spontaneous transition phenomenon to high beam focusing state was observed in a low energy ion beam with high current density extracted through concaved electrodes. This is called as the self-focusing phenomenon. To study the mechanism of this phenomenon, radial profiles of ion and electron current densities, electron density, and electron temperature have been measured by using electrostatic probes with unique structure and Faraday cups with mesh filters which are installed in an ion beam propagation chamber where the high current density ion beam is injected. The radial profiles of electron density and temperature have been successfully measured even under the strong influence of ion beam component. The radial profiles of ion current density has been also measured by using the electrostatic probes.

## 1. Introduction

The self-focusing phenomenon was observed where the divergence of ion beam was spontaneously suppressed without any active electron supply for the charge neutrality [1]. It is very important to understand a mechanism of this self-focusing phenomenon from the view point, not only for physical understanding but also the effective use of the ion beam technology [2]. Therefore, it is necessary to measure profiles of the electron density, temperature and space potential in the ion beam propagation chamber where the ion beam is injected.

To compensate the influence of a strong dose of the ion beam flux flowing onto a probe, a double probe which has specific structures [2], is tried to use. To improve sensitivity and to reduce error in the measurement, the circuit of a voltage sweeping power supply is carefully tuned, and it becomes possible to measure small amount of currents, as low as 0.001 μA, which correspond to the value of low electron density before the transition to the self-focusing state. We will present the results using double probes whose tungsten pins have diagonal pairs of perpendicular and parallel directions to the ion beam, respectively. Moreover, a single probe and a Faraday cup with mesh grids also used.

## 2. Experimental Method

The experimental apparatus consists of three parts. Those are an ion beam source, an ion beam propagation chamber and diagnostic system which are essentially the same as those used in the references of 1 to 6. The ion source is a typical bucket type chamber with cusped magnetic fields. The ion beam propagation chamber is cylindrical with an inner diameter of 300 mm, and a length of 1000 mm. Specific features of this ion beam system is to produce a high current density ion beam by using three electrodes (acceleration, deceleration and grounded electrodes) having concaved shapes for extracting ions from the ion source. The nominal focal length of these molybdenum electrodes is 350 mm. The effective area to extract beam is 80 mmφ with 50 % transparency and each aperture on the electrode is 1.5 mmφ [5]. In the present experimental series, hydrogen gas with 99.9995 % purity is used.

To measure the electron current density, electron density, and electron temperature in the ion beam propagation chamber, two kinds of systems, namely, Faraday cups and electrostatic probes are installed. The distance between the grounded electrode and a beam target plate is 285 mm. Three Faraday cups are set 4 mm behind the beam target plate, and each distance between the cups are vertically 50 mm. The double probe is located 45 mm in front of the beam target plate, and the distance between the electrostatic probe and grounded electrode is 240 mm. The center of the chamber is used as the origin of the measurement ($z$ = 0 mm). The Faraday cups can be vertically swept, $z$ = +90 mm to −80 mm, and the electrostatic probe can be vertically swept, $z$ = +120 mm to − 150 mm, independently. The z-axis is defined as negative value when the probe is set at above the center of the ion beam propagation chamber. The double probe circuit is floating from the ground potential. By using a signal generator and a bipolar power amplifier, the applied voltage on the double probe is swept smoothly from -250 V to 250 V with the pulse length of about 300 s. The one pair of two diagonal pairs is aligned to be a perpendicular direction to the ion beam flux, and the other pair is along with the ion beam flux. In addition, one of four electrostatic probes is used as a single probe. By using the same power supply system with the double probe, the applied voltage on the single probe is swept smoothly from -250 V to 250 V with the pulse length of about 600 s.

Detail results will be presented at the conference.


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