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Measurements of electron temperature and density profiles in an ion source of the low energy ion beam system
低エネルギーイオンビーム源の電子温度及び密度分布計測

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To understand the self-focusing phenomenon of low energy ion beam, an electron temperature, electron density and a space potential in the ion source plasma before and after the transition to a self-focusing state are measured by using an electrostatic probe. The probe is designed to L-shaped structure. The electron density and temperature profiles in an ion source chamber have been measured. The experimental results show that a significant change does not appear in the electron temperature, density and space potential profiles before and after the transition to the self-focusing state.

1. Introduction

Low energy ion beams have been used in many fields, for example, material processing, thin film formation, etching, etc. However, a low energy (here, less than ~200 eV) ion beam with high current density diverges soon after the extraction from a grounded electrode, due to the electric field of extracted ions. In order to prevent the divergence of the ion beam, it is necessary to neutralize the ion charge with electrons. An electron beam is irradiated to the grounded electrode, and secondary electrons are emitted from this electrode to supply slow electrons. Using this method, it was substantiate to obtain the focusing ion beam with high current density [1]. However, a spontaneous self-focusing phenomena of the low energy ion beam around 150 eV was observed even without any active electron supply [2].

The electron density profiles in the ion beam propagation chamber have been measured by using an electrostatic probe [3]. In this study, the spatial profiles of the electron density, temperature and space potential in the ion source chamber has been measured to understand the self-focusing phenomenon by using an electrostatic probe.

2. Experimental setup

Fig. 1 shows a schematic drawing of the experimental apparatus. The ion source is a bucket type with cusped magnetic fields, and this size is 160 mm height, 160 mm width and 190 mm depth. Extraction electrodes consist of an acceleration electrode, a deceleration electrode and a grounded electrode. These electrodes have many aperture (1.5 mmφ) and 1 mm thickness. Transparency of each electrode is 50 %. In addition, these electrodes have a concave shape, and focal length is 350 mm [4]. An electrostatic probe is prepared to measure an electron density, temperature and space potential in the ion source chamber.

Fig. 2 shows a detail drawing of the probe [3]. It composes an alumina tube (4 mmφ), four tungsten wires (0.6 mmφ each). The alumina tube has four holes (0.8 mmφ each), and tungsten wires are installed through each hole, and the length between alumina and tungsten tip is 2.4 mm. Due to the

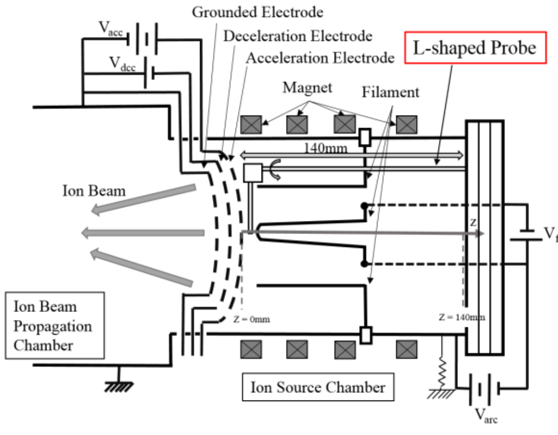

Fig. 1. A schematic drawing of an ion source chamber, electrodes, the ion beam propagation chamber, L-shaped probe and the circuit of power supplies.

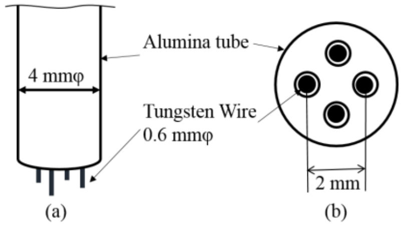

Fig. 2. (a) A side view of the probe, and (b) a bottom view of the probe

limitation of port configuration, the probe cannot be inserted in the axis position. According to this reason, the probe required to be designed to L-shape to measure the center of the chamber, as shown in Fig. 1. A corner part of L-shaped probe is made of an alumina, and this size is 20 mm height, 20 mm width and 8 mm thickness. This probe can be used as not only the single probe but also the double probe. In this experiment, a single probe method is used. To measure three dimensional profiles of the electron density, temperature and space potential, this probe can be horizontally swept and axis rotated. However, the filaments prevent the movement of the L-shape probe. Therefore, a limit of its measurable area is 37 mm from the center axis of the ion source chamber when there is the probe between filaments. Along the axis direction, z, the probe is swept 140 mm. The surface of the acceleration electrode is used as origin of the coordinate axis of the horizontal direction. Hydrogen gas with 99.9995% purity is used. A pressure in the ion source chamber when introducing the gas is ~1.6 mTorr.

3. Experimental results

It was measured that three dimensional profiles of the electron density, temperature and space potential by using the single probe method. To maintain the self-focusing state, it is neccesary to keep the ion beam energy the value less than ~150 eV. In case of the divergent state, the ion beam energy is approximately 140 eV, and of the self-focusing ion beam energy is approximately 170 eV, respectively.

Figure 3 shows the electron density profiles before and after the transition to the self-focusing state. The profile measured at center region of the ion source chamber at z = 70 mm. It seems that the drastical change of electron density profiles was not found before and after the transition to a self-focusing state.

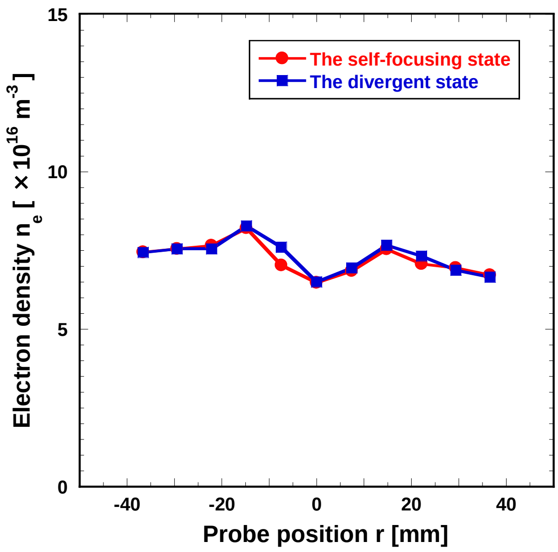

Fig. 3. Electron density profiles at z = 70 mm, square and circle symbols indicate the cases of divergent state and self-focusing state, respectively.

4. Conclusion

It was measured that the three dimensional profile of the electron density, temperature and space potential by using the single probe method. The experimental results show that a significant change does not appear in the electron temperature, density and space potential profiles before and after the transition to the self-focusing state. At this conference, detail measurement results and an analysis result will be presented.

References

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