§31. A Partial-Coaxial Cavity-Type Holey-Plate Ion Source

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A holey-plate surface-wave (HPSW) ion source using a coaxial type open-ended dielectric cavity is very useful for producing high density ion beams.[1,2] However, this source is not easily scalable to large diameters because the microwave enters through the circumference of a dielectric disk, which necessarily acts as a coupler. We have designed a partial-coaxial cavity-type holey-plate (HP) ion source without using a dielectric coupler.

A schematic of the experimental apparatus of the HP ion source using the partial-coaxial cavity is shown in Fig. 1. A microwave of 2.45 GHz is supplied from a 77D-coaxial waveguide. The microwave propagates through a single-taper ridged waveguide to the end of the partial-coaxial cavity. A shorted probe is used to couple the TE_{10} waveguide (54.5 mm × 109 mm) mode to the transverse electromagnetic (TEM) coaxial wave. A quartz disk of thickness t_d =10 mm and diameter d_d =76 mm is placed at the end of the cavity. One side of the quartz disk is flush with the edge of the inner conductor. The other side of the disk is covered with the holey-plate. It should be noted that this disk is not a dielectric antenna for the coupling between the plasma and the surface-wave source. Five different sizes of holey-plates have been designed. They are made from 0.5 mm thick stainless steel sheets. The hole diameter d_h and pitch b are shown in Fig. 1, d_h =1.5, 2.0, 2.5, and 3.0mm. and b=2.6, 3.0, 3.6, and 4.0 mm, respectively. The diameter of the discharge chamber is d_0 =54 mm. An ion beam current reaches a maximum value at d_h =2.5 mm.

The single-aperture extraction system consists of two electrodes. A plasma electrode has a 4-mm-diameter extraction aperture and is made from 1-mm-thick stainless steel. The gap between the two electrodes is 3 mm. Plasma is generated between the holey-plate and the plasma electrode. Since the chamber is electrically floating, the potential of the source plasma is tied to the plasma electrode. A Faraday cup located just outside the extraction system is used to measure the ion beam current. The ion beam is taken out of the process chamber by an oil diffusion pump with an effective chamber pumping speed of 200 ℓ/s. The microwave enters the base of the quartz disk and propagates toward the center. The evanescent electric field is then produced in the plasma production chamber from the holey-plate.

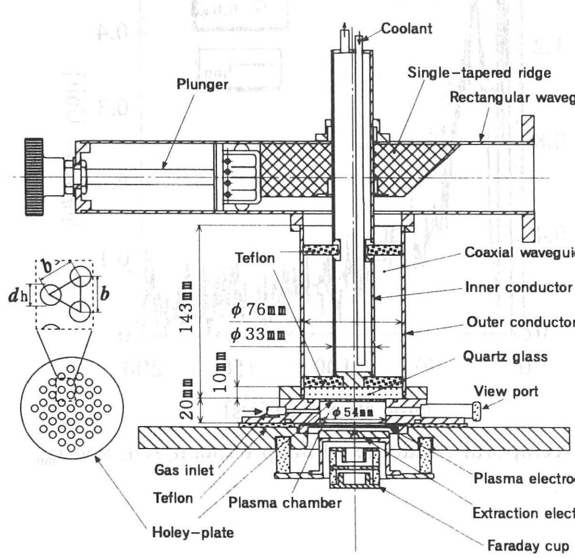

Fig. 1 Schematic diagram of the holey-plate ion source using a partial-coaxial cavity, and schematic for the holey plate structure; diameter d_h and pitch b.

Figure 2 shows the ion beam current versus the extraction voltage for an argon gas pressure P_{p1} =2 Pa, an input microwave power of 150 W, and hole diameter d_h =2.5 mm. The reflected powers were under 10 % of the forward powers. It can be seen that the current exceeds 5.2 mA which is corresponds to 6.6 mA/cm^2. It is possible to maintain a high-current beam at low voltages.

We would like to thank A. Kazama, T. Akahori, and H. Horiike for their assistance.

1) Y. Yoshida, T. Miyazawa, and A. Kazama: Rev. Sci. Instrum. 68 (1997)79.
2) Y. Yoshida, Rev. Sci. Instrum. 69 (1998)1069.

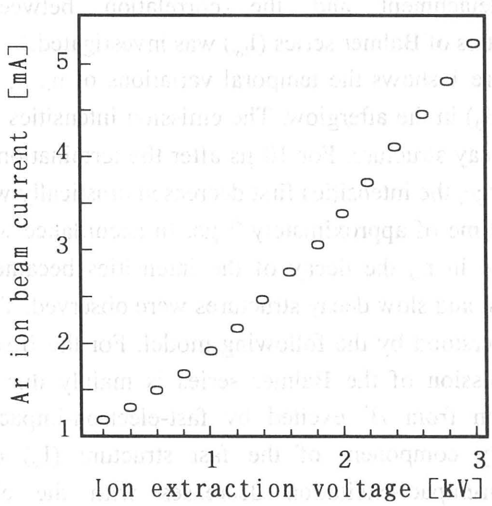

Fig. 2 Ion beam current versus extraction voltage at an argon gas pressure of 2 Pa, an input microwave power of 150 W, and d_h =2.5 mm.