§10. A Comparative Study of Emittance Measurement Methods for He^+ Beam under Various Conditions

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Emittance is one of the basic parameters that characterizes the property of beams extracted from electron and ion sources. Low emittance is especially important for the beam sources in the field of high energy accelerator. The emittance measurement has also become important in the field of thermonuclear fusion research. A small emittance beam is necessary to develop high quality neutral probe beams for future plasma diagnostics and investigate plasma parameters with high spatial resolution in the inner core of plasma in large plasma devices. However, emittance measurements often take a long time and require complex systems. Here, the pepper-pot method and two slit-and-collector type techniques with simple devices are tested for their applicability to measure the emittance of low energy He^+ beams. The pepper-pot type device is the same one used for 80 keV H^- beam1) (Fig.1 a). The one slit-and-collector type device consists of the only one slit and of multi-plate collector stacked stepwisely to minimize any dead space due to insulation (slit-and-multicollector type; Fig. 1 b). The other has a line of fixed twenty two stainless steel blades as a multi-slit and a deep Faraday-cup as a collector (multislit-and-collector type; Fig. 1 c).

Figure 2 shows results of emittance measurement as a function of the He^+ beam current using three types of emittance meters. Emittance measured by the pepper-pot meter is almost the same as those by the multislit-and-collector type at the higher beam current density. For low current density, however, Kapton film is exposed much large number of shots more than 100 to have good contrast. If there are any fluctuations in the ion beam in shot by shot, Kapton film records them and then the total contrast on the film should become larger than the real contrast profile. Figure 2 also shows results of normalized emittance measured by the pepper-pot method by scanning the beam vertically and horizontally. Almost similar values are obtained. Since only one circular electrostatic lens is used for the extractor of the ion source, the extracted ion beam should be axisymmetric, and emittance is expected to be the same in both orthogonal planes. The present results show a good axisymmetry of the beam. Thus, this pepper-pot method has an advantage that it can measure emittance in two directions at the same time. There is another advantage that Kapton film can record positive, negative and even neutral particles.

Among the three systems discussed here, the slit-and-multiplate type meter in the present design is the least reliable, due to the lack of any special treatments for secondary electrons. In fact, a negative signal is observed on every plate far from the main ion beam, which is caused by secondary electrons from collector plates and the wall of the stainless-steel case.

The multislit-and-collector type meter is supposed to be the most reliable device for the measurement of negative ion beams, as the effect of electron is actively suppressed by the magnetic field. As a disadvantage, the fixed multislit plate in vacuum interrupts beam. This system will be much improved by usage of a movable multislit plate.

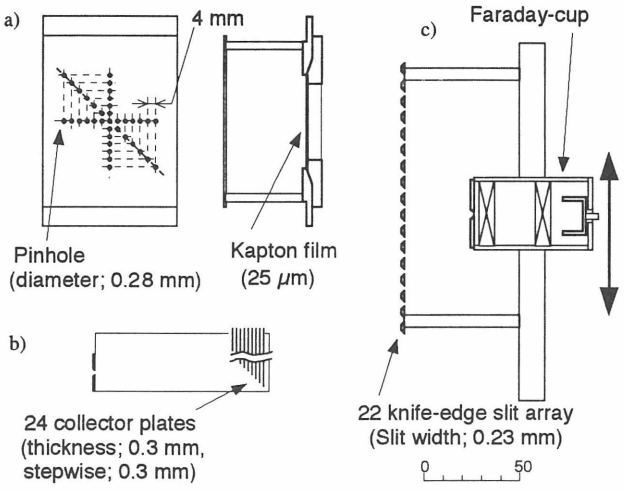

Fig. 1 Schematics of three kinds of emittance gauge.

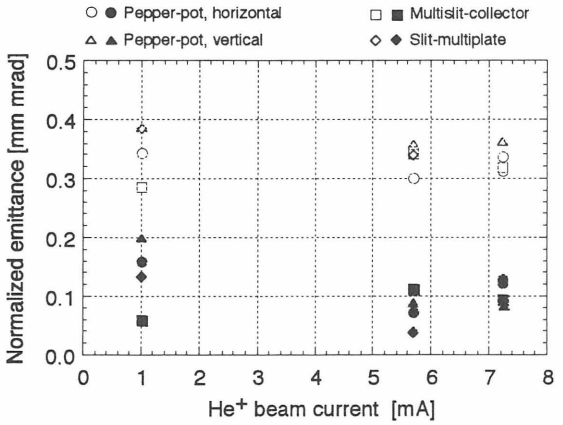

Fig. 2 Dependence of emittance on He^+ beam current. (Open marks; 90 % normalized emittance and closed marks; 50 % normalized emittance).

Reference

1) Guharay, S. K. et al. : Rev. Sci. Instrum., 67, 2534 (1996); NIFS Report No.405 (1996).