§19. Characteristics of High Power RF Ion Source Using Large Area Multi-antenna

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1, Faradat shielded multi-antenna rf ion source

For a large area filament-less rf ion source, we have been developing the Multi-Antenna Type Ion Source (Fig. 1(a)), MATIS. [1-2]. The all-metal antennas are installed inside the vacuum vessel with Faraday screen. The antenna system is desirable in point of the structurally toughness for fusion and industrial application etc. Faraday shielded multi-antenna source produced a high-density plasma (< 170kW, 9MHz, 10ms pulse duration), however, the rf power efficiency for plasma production was fairly low, therefore we developed the new antenna system to improve the coupling between antenna and plasmas. New antenna was designed to increase the RF inductive field at the plasma edge. Four current conductors of the multi-antenna are composed of stainless steel plates (25x200x3t mm), which are electrically connected in parallel. To improve the coupling of the antenna field to the plasma surface, the distance between plasma and the current conductors (D in Fig.1(c)) is reduced to 0.65cm while in the former antenna case, D is ~2cm. Protecting from high voltage rf break down and plasma production inside the FS, fine ceramic powder is filled in the FS.

2, Rf plasma production by the new multi-antenna

Plasma parameters were measured by Langmuir probes [3]. The origin of the coordinate (z) of the probe is taken at the center of the plasma grid (PG), i.e., the center of the extraction hole (in Fig.1 (a)). Former Faraday shielded multi-antenna source produced a high-density plasma with a positive ion saturation current density of 0.15A/cm^2 (3.7mtorr) at ~180kW of rf input power (9MHz, 10ms pulse duration). This power dependence behaves similar to the result of an extracted beam of positive H+ ions with a small extractor. The dependence of ion saturation density (J^+) on input rf power is shown in Fig. 2(a). J^+ reaches to 8A/cm^2 for 30kW of rf power. Compare with the one before modification of antenna, J^+ increases more than few tens of times due to the improvement of the coupling of the antenna fields to the plasma. The electron temperature lies in the range of 7 to 10eV, which has a small dependence on the rf power. The J^+ profile perpendicular to the extraction electrode from PG (along the z-axis) is shown in Fig. 2(b). It appears to be a smooth increasing profile within a region of external magnetic field. There seems to be no abnormal localization of plasma production, leading to a decrease in the efficiency of volume plasma production. Approaching the PG, J^+ decreases by a factor of about 3 with respect to that near the center of the chamber. It would come from cross diffusion across the magnetic filter field.

[1] T.Shoji, Y.Oka, NBI Group, Rev.Sci.Instrum. **77**, 03B513 (2006)

[2] Y. Oka, T. Shoji et al., in *AIP Conference proceedings* **1097**, p282 (2008)

[3] Y. Oka, T. Shoji et al., in *2nd Int. Sym. on Negative Ions, Beams and Sources*, Hida-Takayama, 16-19th Sep. (2010)

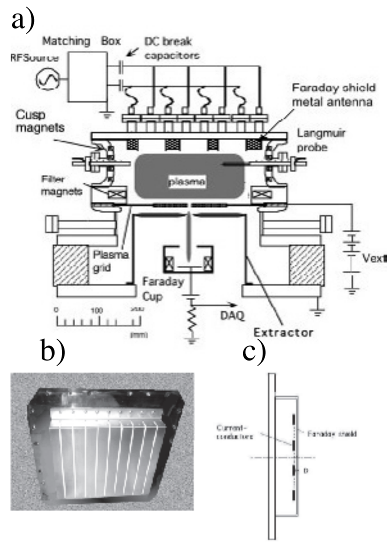

Fig. 1(a) schematic diagram of a multi-antenna type rf ion source. (b)photograph of Faraday-shielded multi-antenna.(c)A cross-sectional sketch of the antenna.

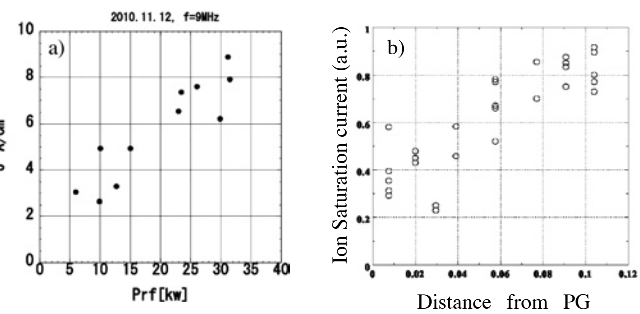

Fig. 2 (a) ion current density (Acm^2) versus rf input power. (b) Ion saturation current profile from the center of PG