§27. Development of Multi-antenna RF Ion Source

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As a filament less system, RF ion sources have several advantages, such as easy maintenance, long operation time, less contamination from the filament metals etc. However, high beam current and large diameter beam are necessary to be developed for the practical NBI source for the fusion research. We have been developing the multi-antenna RF ion source for these purposes [1].

In order to increase the beam current of the RF ion source, the easiest way is to increase the RF power input, however the voltage breakdown on the antenna needs to be solved. The multi-antenna system can reduce the antenna inductance and reduce the RF voltage as a result. The antenna elements are made of copper rods and placed in ceramic pipes to avoid taking the net electron current from the plasma, which raise the plasma potential. The antennas are installed in 35 cm x 35 cm x 18 cm rectangular bucket chamber and are connected electrically outside the chamber as shown in Fig. 1(a). We studied the effect of the antenna segmentations on the plasma production characteristics for two types of the antenna configurations as shown in Fig. (b) and (c). The maximum RF power is 15kW and frequency is 2MHz. The ion saturation current I_{ion} is measured by Langmuir probe. In Fig.2, I_{ion} as a function of the net RF power is shown. In case of the single loop antenna (Fig. 1(b)), I_{ion} tends to saturate around 10kW but the one for the 2-pararel antenna (Fig.1(c)) is still increasing up to 12kW. The RF voltage on the antenna is lager for the loop one but the RF current is larger for the parallel one. The RF plasma production is generally dominated by the electrostatic (capacitive) discharge rather than inductive one in this RF power range. Therefore, it is conjectured that the single loop antenna can make higher plasma density below 10kW but the efficiency of the plasma production is larger for the 2-pararel antenna at higher RF power or higher density. On the basis of those results, more high power RF experiment using the RF power source of 7-28MHz and 500kW is on preparation with multi-antenna system.

Reference

1) Shoji, T, Sakawa, Y, Hamabe, M and Oka, Y., Ann. Rev, NIFS, (2001) 141

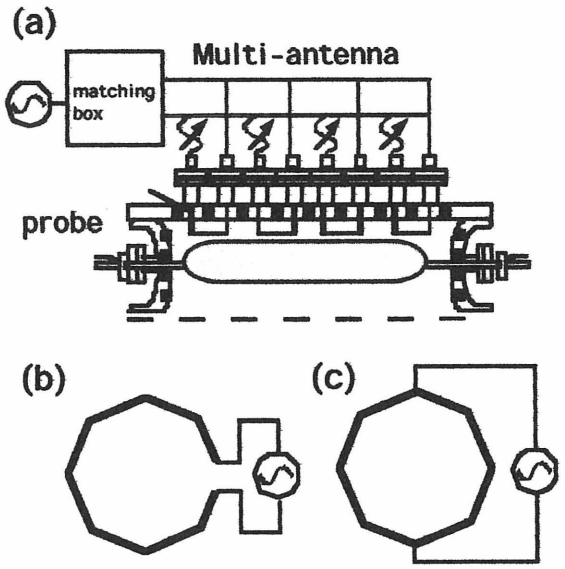

Fig. 1 (a) Multi-antenna RF ion source and segmented antennas, (b) single loop antenna and (c) 2-parallel antenna

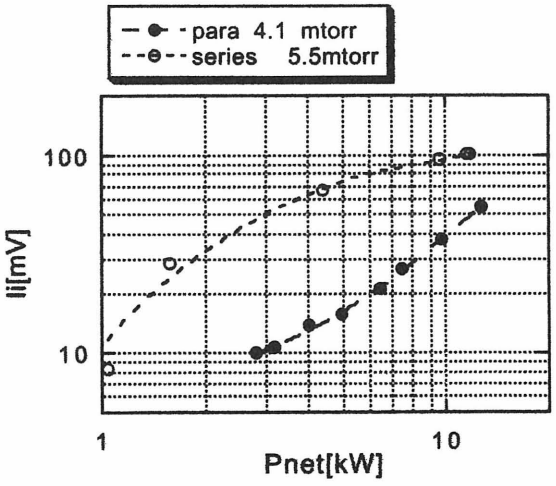

Fig. 2 Ion saturation current at the center of antenna loop as a function of RF input power for single loop and 2-parallel antenna systems. RF frequency is 2MHz.