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

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1, Introduction

We have proposed a multi-antenna type (tandem) rf driven ion source (MATIS) for neutral beam injection (NBI), and studied the basic characteristics [1]. It is composed of a large volume cusp plasma chamber made of a metal wall, and Faraday-shielded multiple current conductors as an internal multi-antenna. In the present research, a new multi-antenna unit is fabricated and tested. The basic principle of the antenna design is to realize a close coupling configuration of the multi-antenna with the Faraday shield, in order to efficiently couple near rf fields to the plasmas.

2, Faraday shielded multi-antenna rf ion source

The structure of a close coupling multi-antenna type rf driven ion source (CC- MATIS) is shown in Fig.1(a). The all-metal antennas are installed inside the vacuum vessel with Faraday screen. Faraday shielded multi-antenna source produced a high-densit y 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 [2]. 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.

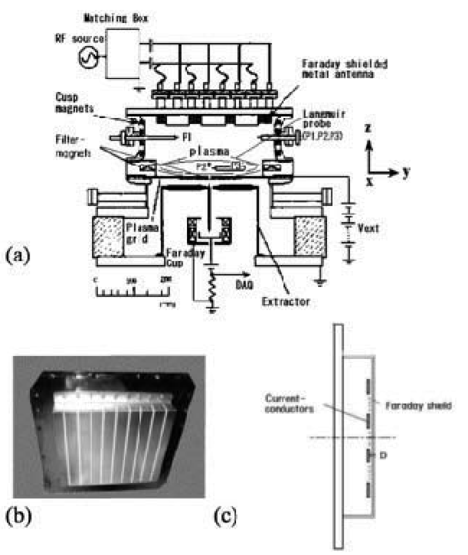

Fig. 1(a) schematic diagram of a multi-antenna type rf ion source. (b)photograph of Faraday-shielded multi-antenna. (c) cross-sectional sketch of the antenna.

3, Ion density profile depending on antenna structure

We investigated the relation between plasma density profile and the antenna structure by changing the number of parallel antenna conductors. The ion saturation current density profile J+sat (x) is measured near the Faraday-shield and the downstream (near the extraction electrode). The ion density is not uniform depending on the number of antenna strips but it becomes more uniform near the extraction electrode and the uniformity is better for 4 stripes than 2strips as shown in Fig. 2. Electrons accelerated by the antenna near fields are lost to the wall to increase the plasma potential. To avoid this effect on the plasma potential, we are developing a ring shape rf conductor, and improving both ion density and plasma potential.

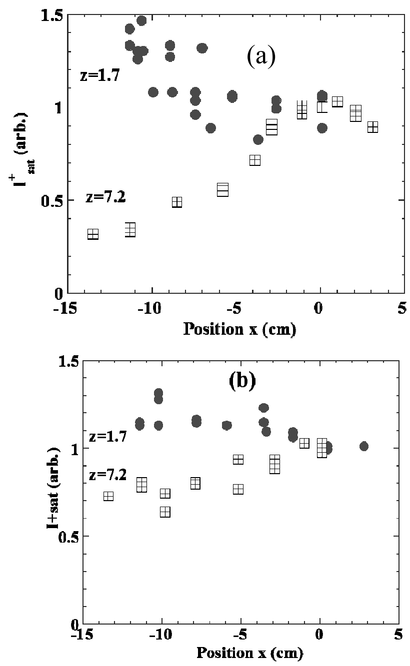

Fig. 2 J+sat (x) profiles along x at z=7.3cm (near Fraday-shield) and 1.5cm (near extraction electrode) for (a) 2 strips and (b) 4 strips of parallel rf conductors.

[1]Y. Oka, T. Shoji, et.al.,, AIP Conf. Proc. , 282 (2009) 1097
[2] Y. Oka and T. Shoji, Rev. Sci. Instrument, 83(2012) 02B106