

## §7. Development of Antenna System for High Power rf Ion Source

Shoji, T. (Dept. Energy Eng. Sci., Nagoya Univ.), Oka, Y.

### 1, Faradat shielded multi-antenna rf ion source

We have been developing the multi-antenna rf system for large size and high power sources [1-2]. The antenna consists of four parallel copper pipes (6φ, 20cm long) inserted into 20φ quartz tubes and is placed in *sus* Faraday shield cage. the antenna is installed in 35 cm x 35 cm x 21 cm rectangular plasma chamber as shown in Fig.1. An extractor installed on the bottom of the chamber has a single hole with 5 mm in diameter. The rf power of 300kW at 9MHz and the pulse width of 10msec is connected to the antenna through the matching circuit.

### 2, High rf power operation

Faraday shielded antenna has been developed for high rf power operation with low plasma potential ( $V_p$ ). Plasmas are produced by the inductive rf electric fields near the antenna and diffuse toward the extraction electrode. The available rf power was limited around 40kW for no Faraday shielded antenna due to the break down at antenna inside the chamber. The maximum ion current density ( $I_i$ ) and electron temperature ( $T_e$ ) are  $\sim 15\text{mA/cm}^2$  and  $\sim 20\text{eV}$ , respectively, and  $V_p$  increases with  $P_{rf}$ . With the Faraday shielded antenna, available input  $P_{rf}$  and the resultant  $I_i$  increase as shown in Fig. 2. The discharge mode changes around 90kW and  $I_i$  tends to saturate around 200kW. The hydrogen gas pressure dependences on  $V_p$ ,  $T_e$  and  $I_i$  are shown in Fig. 3.  $T_e$  and  $V_p$  are kept  $<10\text{eV}$  and  $<5\text{V}$  for  $P_{rf}=160\text{-}170\text{kW}$  and those values are reduced compare to the case without Faraday shield.

At rf power of 130-160kW,  $\text{H}^+$  ion current reached about 0.05mA. This corresponds to a negative ion current density of  $0.25\text{mA/cm}^2$  at the PG hole. Under a high power level,  $0.7 \sim 1.5\text{mA/cm}^2$  appeared.  $\text{H}^+$  ion current decreased with the increase of gas pressure. In the

extraction of positive ions, maximum ion current density reached  $30\text{mA/cm}^2$  in the external magnetic filter.

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

[2] T. Shoji and Y. Oka, Rev, NIFS, (2006) 142

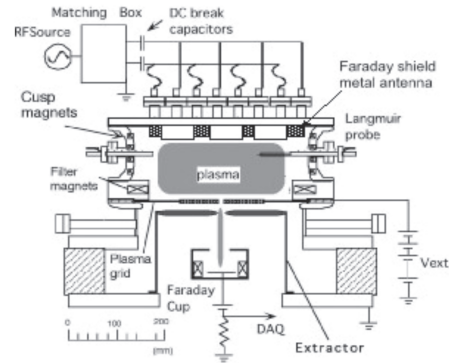


Fig. 1 4-para multi-antenna rf ion source

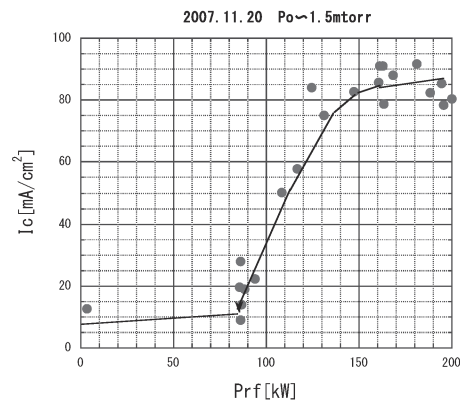


Fig. 2 Dependences of ion current ( $I_i$ ) on rf power for Faraday shielded antenna.  $P_0 \sim 1.5\text{mtorr}$  (H).

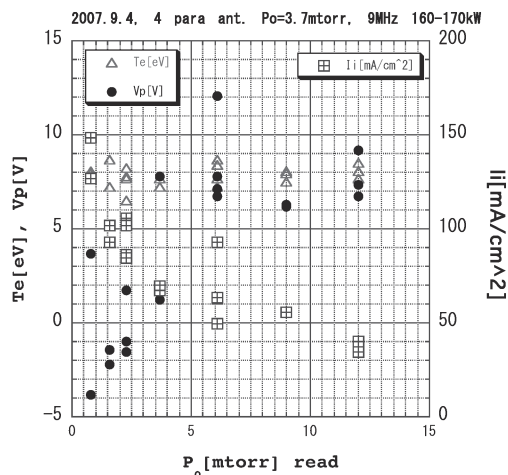


Fig.3 Dependences of  $T_e$ ,  $V_p$  and  $I_i$  on H gas pressure.  $P_{rf}=160\text{-}170\text{kW}$ .