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高密度ヘリコンプラズマによる外部印加磁気ノズルの変形の検討

Modification of a magnetic nozzle field by a high-density helicon plasma

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An electrodeless helicon plasma thruster using a spontaneous ion acceleration by a current-free electric double layer and/or an ambipolar electric field formed in magnetically expanding radio-frequency plasmas has been suggested and investigated actively [1]. According to a recent result of direct thrust measurement, efficient fuel gas ionization and optimization of the magnetic nozzle are the key issue to improve the thruster performance [2]. When increasing the plasma density, the magnetic field lines are modified by the spontaneous plasma current [3]. Understanding of the magnetic field modification is an important issue relating to the plasma detachment phenomenon. Here a modification of the applied magnetic nozzle is experimentally investigated in a current-free helicon magnetically expanding plasmas.

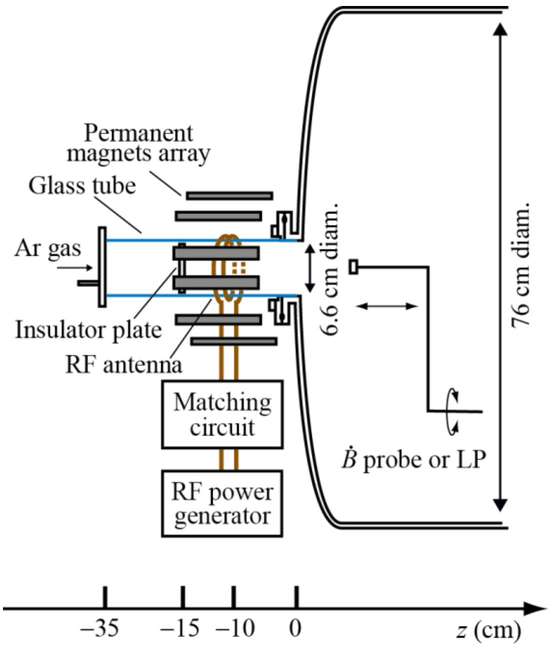

Figure 1: Experimental setup.

Figure 1 shows schematic of the experimental setup. The machine has a 6.6-cm-diam and 35-cm-long glass source tube and a 76-cm-diam and 100-cm-long grounded diffusion chamber, which is evacuated to a base pressure of 10^{-4} Pa by a diffusion/rotary pumping system. The interface between the source tube and the diffusion chamber is defined as z = 0 cm and the upstream side of the source is terminated by an insulator plate at z = –15 cm, where z is the axial position. The magnetic nozzle is formed near the source exit by an array of permanent magnets surrounding the source tube. Argon gas is introduced from the upstream side of the source and the neutral pressure is maintained at 60 mPa. The double turn rf loop antenna around the source tube at z = –10 cm is powered from a 13.56 MHz and 4.5 kW rf power generator, where the generator is pulsed at the repetition rate of 1 Hz and pulse width of 20 msec. The local change of the magnetic field during the discharge and the plasma density are measured by axially and radially movable $\dot{B}$ probe and Langmuir probe (LP), respectively. The plasma density is ~10^{12} cm^{-3} and 10^{10}-10^{11} cm^{-3} in the source region and magnetic nozzle, respectively.

Under the above-mentioned conditions, the diamagnetic magnetic field perturbation is detected in the source tube. In the magnetic nozzle, on the other hand, the diamagnetic and paramagnetic perturbations are observed at the radial center and the peripheral region, respectively, and vice versa. This is found to depend on the magnet configuration. The results will be discussed with the measured plasma profiles.

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