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永久磁石を用いた高周波プラズマの特性評価
Characteristics of Radio Frequency Plasma Using Permanent Magnets

岸謙介，山瀬智也，桑原大介，篠原俊二郎
K. Kishi, T. Yamase, D. Kuwahara, S. Shinohara

農工大工
TUAT

For a deep space exploration, electric propulsion systems are more efficient than chemical ones, because of their higher specific impulse, which is suitable for long-term space missions with less propellant. In the conventional electric propulsion systems, e.g., ion thrusters, their lifetime are often limited due to electrode erosion by a collision with plasmas. In order to make the longer lifetime and the higher efficiency, we have been developing new electrodeless plasma propulsion systems with a high-density (~10^{13} cm^{-3}) helicon plasma source, as a Helicon Electrodeless Advanced Thruster (HEAT) project [1]. This acceleration principle uses the Lorentz force F_z, the product of the induced azimuthal current j_θ in the plasma and the external static radial magnetic field B_r.

In recent years, a number of researches of a helicon plasma thruster using a magnetic nozzle have been developed [2,3]. This takes advantage of efficient helicon plasma production, obtaining high-density plasma (~ 10^{13} cm^{-3}) with a wide range of external conditions. A magnetic nozzle with the strong magnetic field is important to be applied to the electrodeless plasma propulsion system because of two following benefits: an increase of an electron density [4] and a reduction of a radial plasma loss [5]. Therefore, we have developed an external magnetic field source using permanent magnets, which can generate strong magnetic field more easily without power supplies compared to the electromagnets

This study deals with characteristics of radio-frequency (RF) plasma performance using a magnetic nozzle system in a small-diameter helicon source named Small Helicon Device (SHD), as shown in Fig. 1 [6]. The magnetic field was up to 0.3 T by the developed permanent magnet system (Fig. 2). Here, the plasma was generated at an RF frequency of 12 ~ 150 MHz with an RF power up to 1 kW.

In the presentation, we will show effects of the developed magnet system on the plasma performance: we have examined a relationship between magnetic fields, RF frequencies, and argon gas pressures by measuring an electron density n_e and ion velocity v_i in the radial and axial directions by the use of an L-shaped Mach probe. In addition, to verify and improve the effect of permanent magnet system on the plasma, we will attempt to use another gas species, and have a combined operation with permanent magnets and electromagnets.

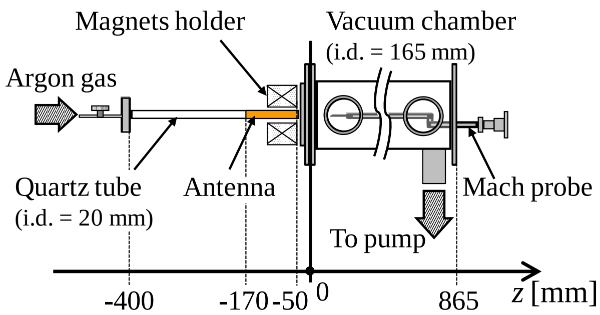

Fig. 1　Schematic of SHD.

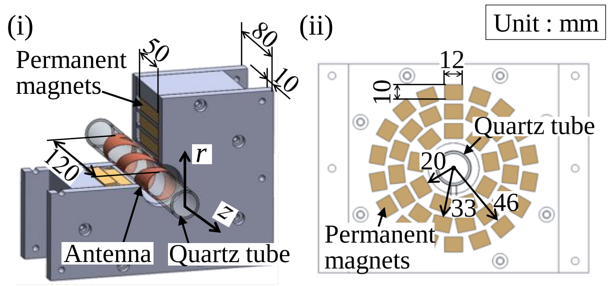

Fig. 2　Layout of permanent magnets.
(i) Shematic of magnets holder.　(ii) Arrangement of the magnets from the front side.

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