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高密度ヘリコンプラズマによる完全無電極電気推進の研究(VII)：小口径ヘリコンプラズマ源開発

Study on Completely Electrodeless Electric Propulsion System using High-Density Helicon Plasma (VII): Development of Small Helicon Plasma Source

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In long-term space missions, an electric propulsion system is more suited than chemical propulsion system for higher specific impulse. However, an operation lifetime of a conventional electric system, e.g., Hall thruster, is limited by a damage of electrodes due to a direct contact directly with a plasma. To solve this problem, we have proposed electrodeless plasma propulsion system, using a high-density (~ 10^{13} cm^{-3}) helicon plasma.[1-4]

In the case of producing a helicon plasma with a very small diameter, this source will contribute to the development of a lightweight, small thruster such as an attitude control thruster. Alternatively, several units can be combined to provide greater thrust. The source may also have industrial applications, such as the coating of the inner wall of a thin tube.

In this paper, to investigate the characteristics of a helicon plasma with a very small diameter, we have developed Small Helicon Device (SHD, as shown in Fig. 1)[5] and measured an electron density n_e under the various conditions in a wide range of a radio frequency. Here, a small quartz tube is connected to a vacuum chamber which is 165 mm in inner diameter and 865 mm in axial length, pumped by a rotary pump through a turbo-molecular pump. Here, various diameter tubes can be connected to a gauge port adapter (left part in Fig. 1). To measure a fill pressure, an ion gauge and a gas feeder are connected to an upstream flange. A base pressure in the vacuum chamber is ~ 7 × 10^{-5} Pa.

In Fig. 2, n_e near the antenna region vs. P_{rf} is plotted with i.d. of 20 mm. From this, n_e was increased with P_{rf} under all rf frequencies of 7, 50 and 70 MHz, and was nearly the same with or without the field regardless of the rf power range. Although a density jump by a factor of ~ 100 to be close to 10^{13} cm^{-3} was observed with only f = 7 MHz at P_{rf} ~ 700 W, n_e in the cases of 50 and 70 MHz excitations increased monotonically with P_{rf}. This jump is considered as a mode transition from Inductively Coupled Plasma (ICP) to a helicon plasma.[6] In the case of f = 7 MHz in the presence of the magnetic field and P_{rf} ~1,000 W, n_e was lower than the case without magnetic field. Here, a stable discharge with f = 7 MHz and without the field was not observed with P_{rf} < 800 W.

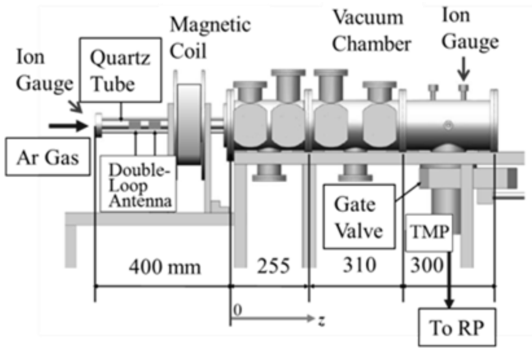

Fig. 1　Small Helicon Device (SHD).

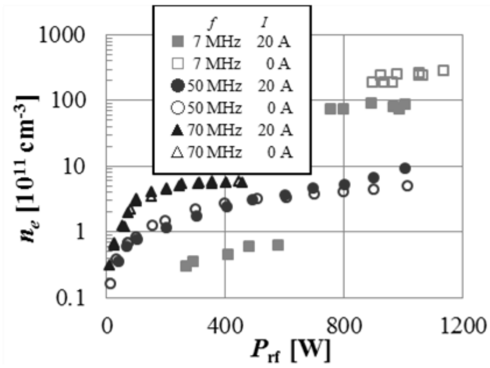

Fig. 2　Electron density n_e vs input rf Power P_{rf}.

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