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Study of Helicon Plasma Thruster using Internal Gas Feeding Method

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Nowadays, electric propulsion devices have been attracting attention due to the increasing demands for deep space exploration and reducing prices of artificial satellites. Here, a thrust range of electric thrusters is extremely wide. Main thrusters for manned space explorers utilize megawatt class power supplies. Satellites such as telecommunication satellites require the range from a few kilowatts to tens of kilowatts. Meanwhile, CubeSat and NanoSat range from a several to several tens of watts. Although most of the currently operated electric propulsion systems are efficient, the plasma generation and acceleration electrodes that directly contact the plasma have serious erosions, which shortens the thruster operational lifetime.

A helicon plasma thruster (HPT) has been proposed as a long-life and high-thrust thruster, e.g., [1]. Here, a helicon plasma, which is well known as an efficient high-density plasma generation method, is a type of Radio-Frequency (RF) plasma with a magnetic field. It has a potentially long lifetime, since the helicon plasma antenna, wrapped around the outer side of the insulation tube, does not directly contact the plasma.

Here, an internal gas feeding method has been newly proposed to increase the thrust performance of the helicon plasma. Figure 1 shows a conventional HPT and a proposed HPT using the internal gas feeding. In conventional methods, the propellant neutral gas is supplied via the upstream of a discharge tube. On the other hand, the proposed method supplies the gas into an inner region of the plasma directly. The main objective of this method is to alleviate the depletion of neutral particles in the high-density plasma core. Here, the depletion phenomenon causes a limit of maximum central electron density obtained [4]. Therefore, since the plasma thrust is proportional to the electron density, this thrust is also limited, causing a problem in getting better plasma performance. In addition to this proposed method, to reduce the backflow of the plasma and the plasma wall loss, we have tried to put the RF antenna and the feeding pipe in the downstream region of the magnetic nozzle. Here, the reduction of the wall loss by the proposed method can be an extremely important performance improvement, especially for a high-power thruster.

For a proof of the principle, an internal gas feeding method using a small tube with a hole inserted plasma directly was tested. If successful, this tube will be replaced for a prepared Laval nozzle [5], which can feed a concentrated gas beam to the core region of the plasma. In our preliminary experiment, 51% increased thrust force has been obtained at the RF power of 3 kW and a gas feeding rate of 100 sccm (Ar). In order to understand the mechanism of this method, we have been measuring distributions of plasma parameters using various diagnostics; electron density (Langmuir probe, microwave interferometer [6]), ion and neutral flow velocities (laser induced fluorescence [7]), and thrust force (target type thrust stand [8]).

In the presentation, detailed experimental setup and improved experimental results will be shown.

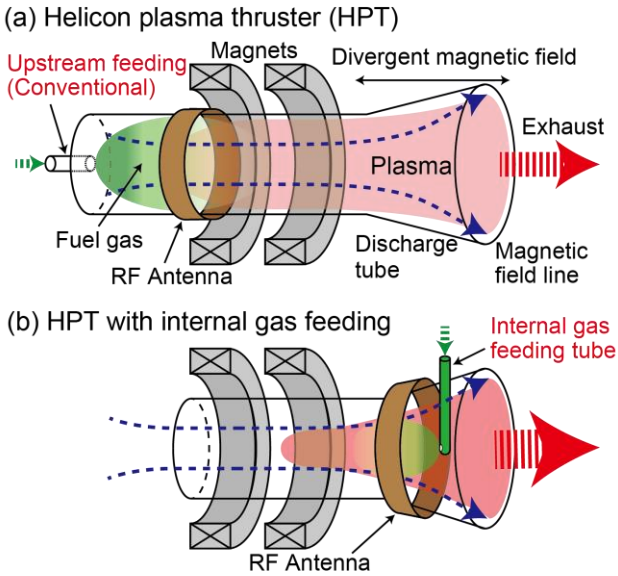

Figure 1 Concept of conventional helicon plasma thruster and HPT with internal gas feeding.

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