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# Study of advanced gas feeding methods for radio-frequency plasma thruster

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Electric propulsion devices have been attracting keen attention due to the increasing demands for deep space exploration and reducing prices of artificial satellites. Here, a thrust range relating to electric thruster power of 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 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 radio-frequency (RF) plasma thruster has been proposed as a long-life and high-thrust thruster, e.g., [1-3]. Here, a helicon plasma, which is well known as an efficient high-density plasma generation method, is a type of RF plasma with a magnetic field. It has a potentially long lifetime, since an excitation antenna, wrapped around the outer side of the insulation tube, does not directly contact the plasma.

Here, two internal gas feeding methods has been newly proposed to increase the thrust performance of the RF plasma. In conventional methods, the propellant neutral gas is supplied via the upstream of a discharge tube. On the other hand, both proposed methods aim to supply the gas into an inner region of the plasma directly. The main objective of these methods 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, the maximum thrust is also limited, causing a problem getting better plasma performance. In addition to these proposed methods, to reduce the backflow of the plasma and the plasma wall loss, we have tried to put the RF antenna 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. First, a supersonic gas puffing (SSGP) method uses a concentrated narrow gas beam generated by the Laval nozzle and a high-pressure gas [5]. This method can supply the gas in center axis where the neutral depletion is occurred. Second, an internal feeding tube (IFT) method is proposed to confirm effects of the core feeding [3]. This method supplies the gas using a small ceramic tube which inserted into the plasma core directly. Therefore, this method does not prevent the plasma loss by the tube, and the damage of the tube. The IFT method works a simulation experiment on the central feeding method.

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 velocity (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.

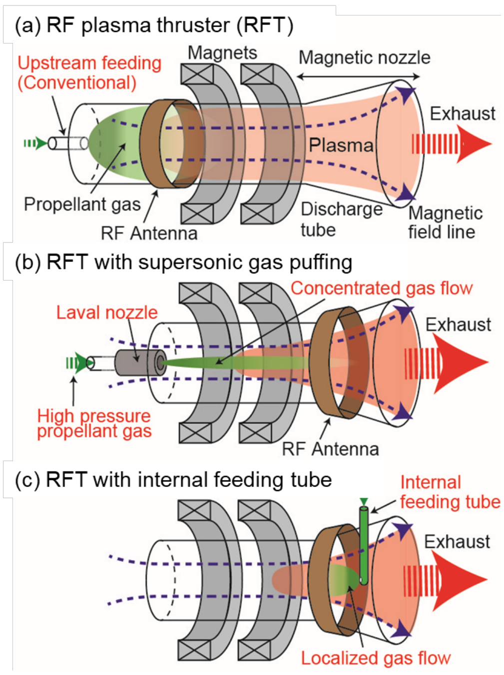


Fig. 1. Schematics of various RF thrusters, (a): basic RF thruster (RFT), (b) RFT with supersonic gas puffing, and (c): RFT with internal feeding tube.

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