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Thrust Characteristics of Electrodeless Plasma Thruster using RF Discharge with Non-Uniform Magnetic Field

Yuya Oshio[1], Kaichi Shimura[1], Kazutaka Matsushima[1], Tomohiro Shimada[1], Hiroyuki Nishida[1]

[1] Department of Mechanical Systems Engineering, Tokyo University of Agriculture and Technology

y-oshio@cc.tuat.ac.jp (speaker):

Several space missions using the electric propulsion, which ionizes propellant gas and accelerates the plasma, are proposed recently. In the conventional electric propulsion, for example ion thruster, hall thruster and arc jet and so on, the breakdown of the electrode system is inevitable due to wear by the plasma collision. Therefore the new type electric propulsion system called electrodeless plasma thruster which is prevented the direct contact with between the electrode and the plasma was proposed[1]. The electrodeless plasma thruster utilizes electrodeless Radio Frequency (RF) discharge and electrodeless plasma acceleration. This type thruster has potential of settlement of the issue of the electrode failure of the electric propulsion. However, the thrust performance of the electrodeless plasma thruster is lower than the conventional type. To improve performance, additional acceleration method was proposed and researched, but the enough thruster performance is not achieved in feasible operation parameter[2].

We focus on the improvement of the plasma generation efficiency and the exhaust efficiency by coupling between the RF antenna and the non-uniform magnetic field. Figure 1 shows schematic diagram of the RF plasma thruster with non-uniform magnetic field. We employ the cusp magnetic field as the simple non-uniform magnetic field and triple loop antenna as the RF antenna. The thrust performance of this type thruster strongly depends on the positional relation between the magnetic field configuration, the RF antenna and the thruster exit. The objective of this study is optimization of these configuration. We will discuss and reveal the suitable RF antenna position and shape and the magnetic field configuration in the conference.

The experimantal system is consisted of the vacuum chamber (ϕ 700 mm, 1200 mm in length), vacuum pump systems, RF systems, thruster head, the thrust thrust and plasma mesurement system in the downstream of the thruster as shown in Fig.2. Thrust is measured using by the torsion balance type thrust stand. The operation conditions are 13.56 MHz, 100-1000 W and 1.2 mg/s of Ar for the RF discharge and 51 mT of maximum magnetic field strength. In this study, we measure the thrust performance by changing the RF antenna and the magnetic cusp position against the thruster exit remaining the distance between the RF antenna and the magnetic cusp. The typical experimental results are shown in Fig 3. The RF antenna position is 20 mm downstream than the magnetic cusp and z shows the RF antenna position, which the origin of z is thruster exit. The maximum thrust performance is obtained at z=-5 mm. These results mean that the RF antenna and the magnetic cusp should be locate near the thruster exit to improve thrust performance.

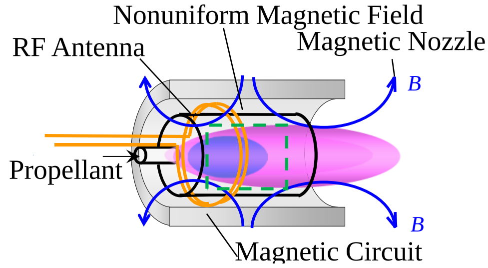

Figure 1 RF Plasma Thruster with non-uniform magnetic field.

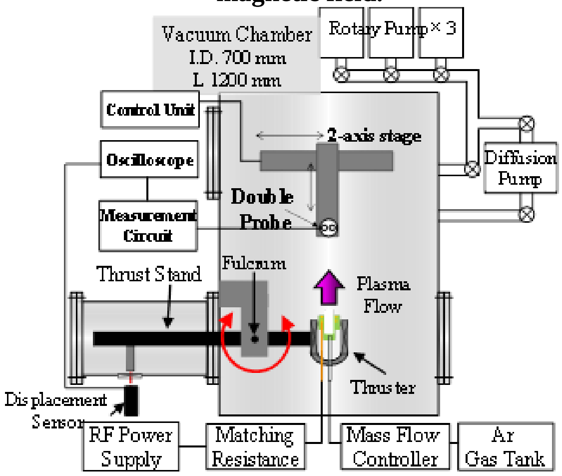

Figure 2 Experimental Setup.

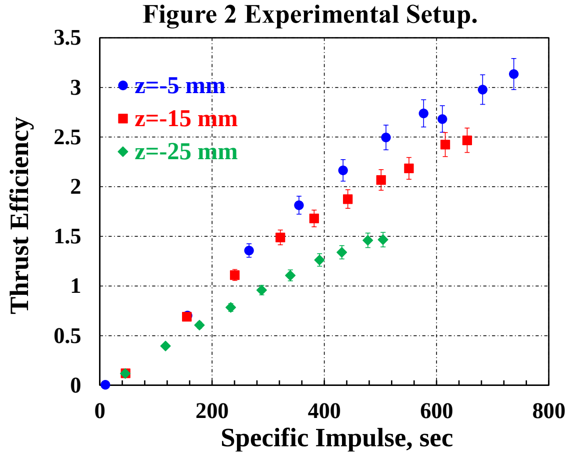

Figure 3 Thrust performance in several antenna position and magnetic field configuration.

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