

## Development of 5kW Class Anode Layer Type Hall Thruster

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### Abstract

To develop 5 kW class anode layer type Hall thruster, the effect of magnetic field configuration on thruster performance were investigated.

### 1. Introduction

For space missions, the reduction of craft size and cost are required. Electric propulsion systems, Ion thrusters and Hall thrusters, enable above requirements and have been demand as a main propulsion system such as 457M<sup>[1]</sup>, HERMeS<sup>[2]</sup> and D-160<sup>[3]</sup> for the missions such as Manned Mars Mission, Asteroid Redirect Mission and construction of the Space Solar Power System. The features of Hall thruster are high thrust density and wide power operational range<sup>[4]</sup>. In addition, Hall thruster has the long life, more than 5000 hours, and efficiency of more than 50% with specific impulse of 1500-2000 s. Therefore, Hall thruster is suited to orbit transfer of the spacecraft and North-South Station Keeping (NSSK) of geosynchronous satellites. SMART-1, a spaceship to survey the moon, was adopted Hall thruster as a main propulsion system<sup>[5]</sup>.

In this paper, in order to improve the thrust efficiency, the effects of magnetic field configuration on thrust performance, that is, thrust and thrust efficiency were investigated and discussed.

### 2. Experimental

In this study, we used 5 kW class anode layer type Hall thruster, named RAIJIN94, which is designed at Kyushu University. The sectional view is shown in Fig. 1. The outer diameter and inner diameter are 94 mm and 60 mm. 1 inner coil is set at center of the thruster and 4 outer coils are set at each corner. Thrust was measured by pendulum type thrust stand which was fabricated at

Kyushu University and its uncertainty was 2.6%. Thrust efficiency and oscillation amplitude were calculated with the following equations. The test was conducted in space science chamber in ISAS/JAXA.

Magnetic field configuration can be change by changing the ratio of inner coil current to outer coil current. In this test, two type anodes were used; nominal type and boss type shown in Fig.2.

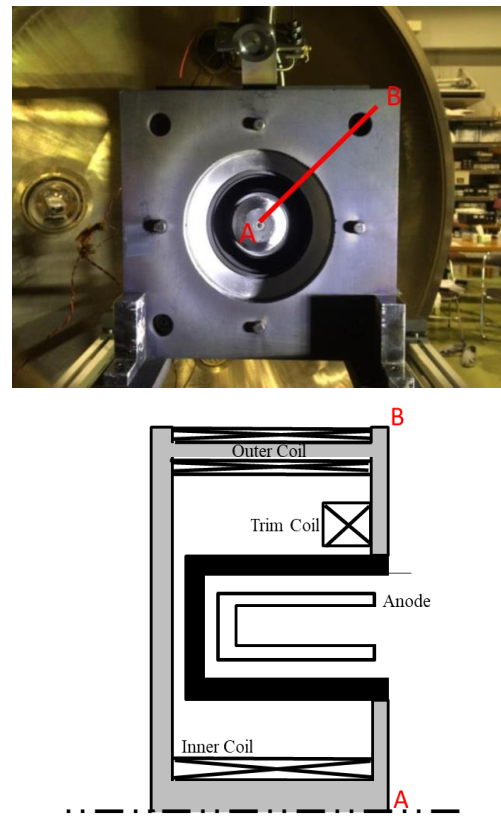


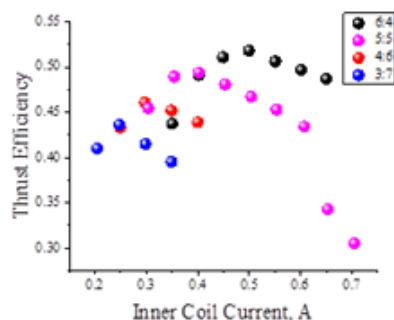
Figure 1 sectional view of Hall thruster

$$\eta_t = \frac{F^2}{2(\dot{m}_a + \dot{m}_c)V_d I_d} \quad (1)$$

### 3. Result

#### 3.1 Magnetic field configuration effect

Fig. 2 shows the coil effect on the thrust efficiency at discharge voltage of 300 V and mass flow rate of 4.9 mg/s. In this condition, the ratio of inner coil current to outer coil current was changed. When the ratio of inner coil current to outer coil current is 6:4, the thrust and the thrust efficiency were maximum. Then, thrust was 95 mN at inner coil current of 0.45 A and outer coil current of 0.3 A. Thrust efficiency was 52% at inner coil current of 0.5 A and outer coil current of 0.33 A. This would be because the line of force was improved to straight at the plasma generation area, when the ratio of inner coil current to outer coil current is 6:4. This would tend to improve the thrust performance because magnetic force line corresponds to equipotential line.



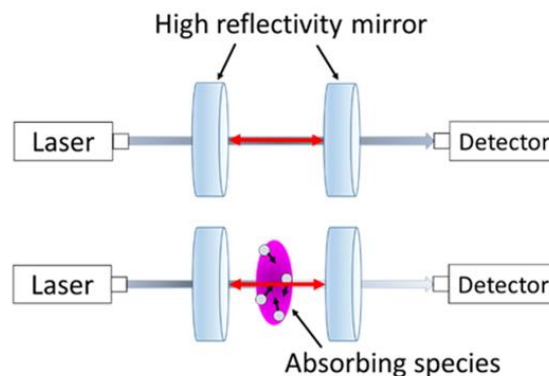
**Figure 2** Coil effect on efficiency

### 4. Conclusions

Investigation of thrust dependency on magnetic field configuration was performed. The optimum ratio of inner coil current to outer coil current was 6:4 at discharge voltage of 300 V

### 5. Future work

To achieve long life of Hall thruster, optimization of life time which means erosion measurement is required. However, endurance test needs so much cost in expense and human resources. Therefore, as a real-time measurement, cavity ring down spectroscopy (CRDS) which shown in Fig. 3 will be used.



**Figure 3** Mechanism of CRDS

### Acknowledgment

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