Development of low-power micro cylindrical hall thruster "SCHT-1"

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Abstract: Development of Hall thrusters for nano, small and low-power satellites is expected. In lowering Hall thruster power, the Cylindrical Hall thruster is more advantage than conventional coaxial-type Hall thrusters. In this study, a very low power Cylindrical Hall thruster" SCHT-1" for Nano-satellite was designed, and in order to investigate the cause of the decrease in thrust performance, the diverging shape of plume are measured. As a result, the cause of low propulsion performance of SCHT-1 is shown due to be plasma divergence.

I.Introduction

IN the last twenty years, the nano-satellite by the private companies and universities has developed greatly because deployment of piggyback launch business and deploying nano-satellite from ISS were started. In Japan, more than 30 nano-satellites were launched by several universities since 2002. In the future, development of nano-satellite which can be advanced mission such as the transfer maneuver or deorbit, and construction of satellite constellation are expected.

Tokai University focused attention of these points, started to development of micro-size cylindrical hall thruster (CHT) which can be onboarded on nano-satellite as a next step of nano-satellite since 2016. CHT has circular cross-sectional ceramic discharge chamber without the inner magnetic pole and form a cusp-shaped magnetic fields. This magnetic field construction can avoid a decrease thrust efficiency due to down-sizing in a typical magnetic layer type hall thruster.

In a previous study, we developed new micro CHT named "SCHT-1" which are based on TCHT-5, and the performance characteristics were measured. As a result, SCHT-1 had a high efficiency of 10% in the power range of 100W and specific impulse were 700 sec. Compared with TCHT-5, although the discharge characteristics were almost the same, but a decreased the specific impulse. In this study, in order to investigate the cause of the decrease in thrust performance, the diverging shape of plume are measured.

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II.Experimental Method and Apparatus

The appearance and cross-sectional view of SCHT-1 are shown in Figure 1 and 2. The anode and a propellant feed tube also serving as power line located at the upstream end of the circular cross-sectional part is made of oxygen-free copper (Cu). The discharge chamber made of Boron Nitride (BN), the inner diameter is 14mm. SCHT-1 are employed Neodymium (Nd) permanent magnets, and 8 pieces Nd magnets is mounted at the periphery.

Experimental facility is shown in Figure 3 and 4. SCHT-1 was operated in a stainless-steel vacuum chamber with 0.6 m in diameter and 1.6 m in length. The chamber can reduce the pressure to 6.0×10^{-3} Pa by combining the turbo molecular pump and rotary pomp. Langmuir probes for measuring ion currents are shown in Figure 5. This device consists of 25 probes, it can be measuring ion currents at same time. During the experiment, these probes were applied -30 V. In this experiment, used only vertical and horizon probes, a discharge current to ion current ratio were measured.

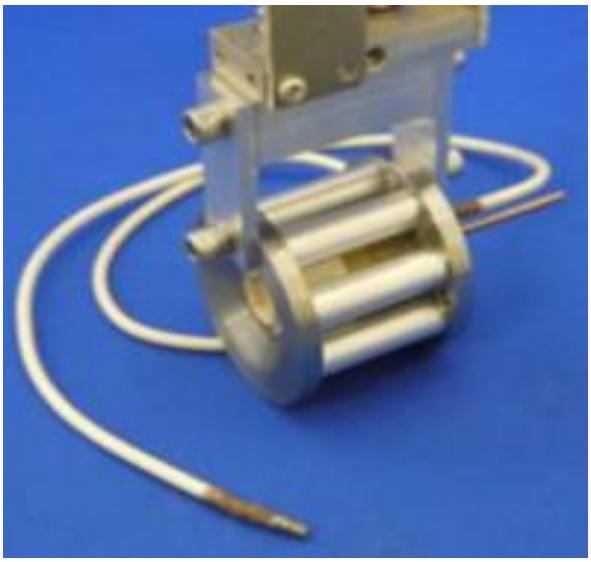

Figure 1. Micro Cylindrical Hall Thruster "SCHT-1".

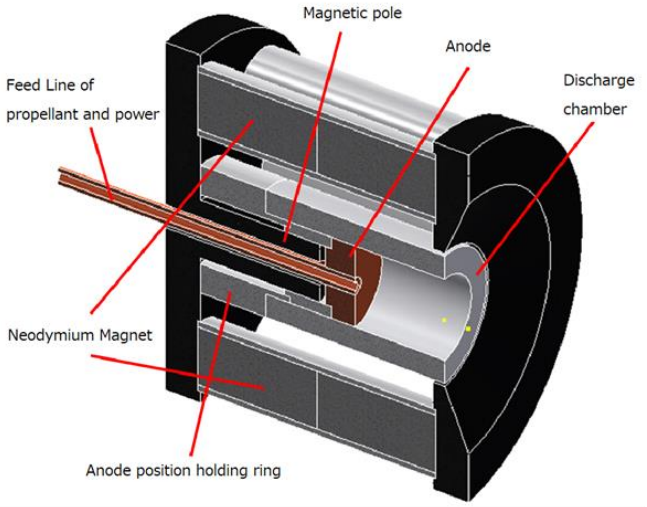

Figure 2. Cross-section of SCHT-1.

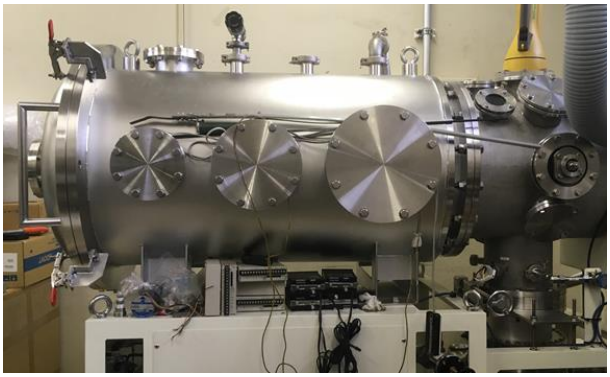

Figure 3. Vacuum chamber.

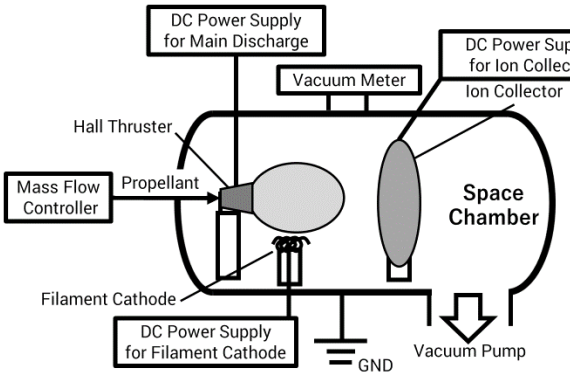

Figure 4. Vacuum chamber.

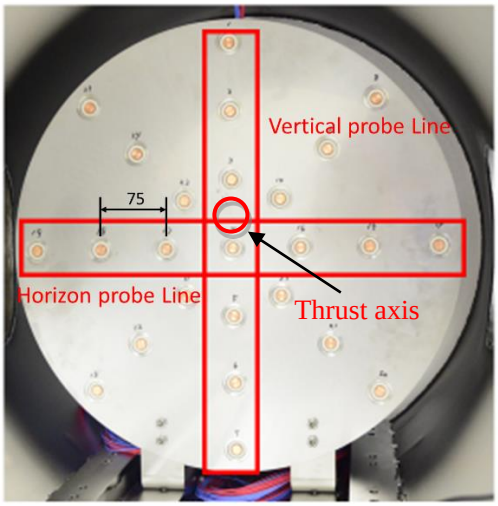

Figure 5. Vacuum chamber.

III.Experimental Results

Figure 6 shows SCHT-1 at operation. It is shown that the plasma collided the filament, the plume shape was disturbed. Figure 7 and 8 shows the characteristics of the discharge current to ion current ratio of vertical and horizon probes. When the length from SCHT-1 to probe was 270 mm, a low ion current region was measured in near the thrust axis. At the increase the length, this region was disappeared, distribution became to chevron shape. For these reasons, it is thought that the almost generated plasma was scattering to outer circumferential direction.

On the other hand, although horizon line probes also show the same trend, but the left side of thrust axis region shows the low ion current. This phenomenon can be assumed that plasma collided to the filament cathode.

For these reasons, the cause of low propulsion performance of SCHT-1 is shown due to be plasma divergence. In the future, SCHT-1 will be add trim coils due to improve the shape of the magnetic field.

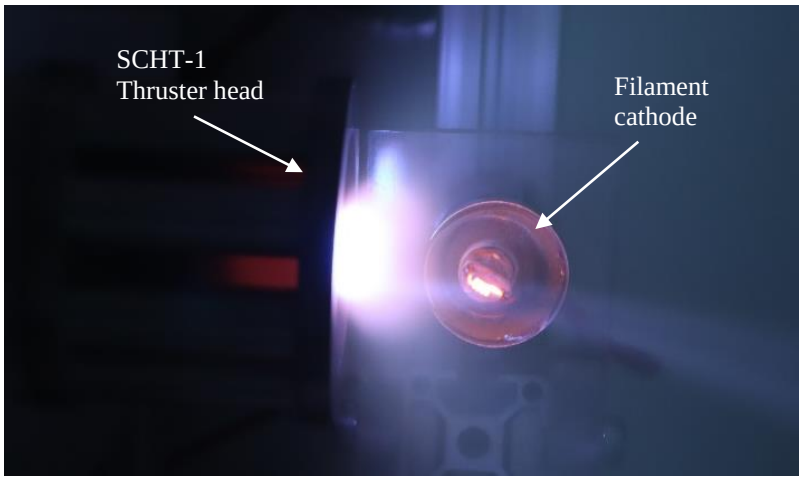

Figure 6. Under operated SCHT-1.

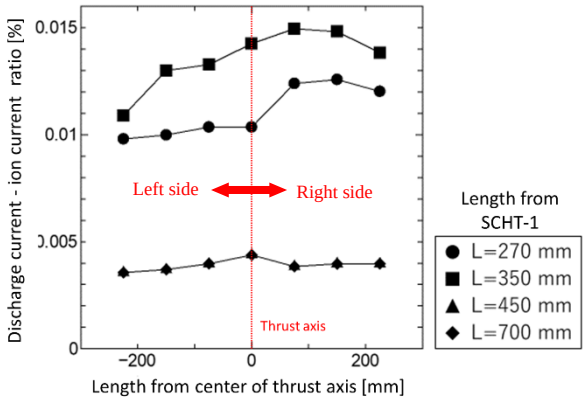

Figure 7. Horizon characteristics of discharge current to ion current ratio.

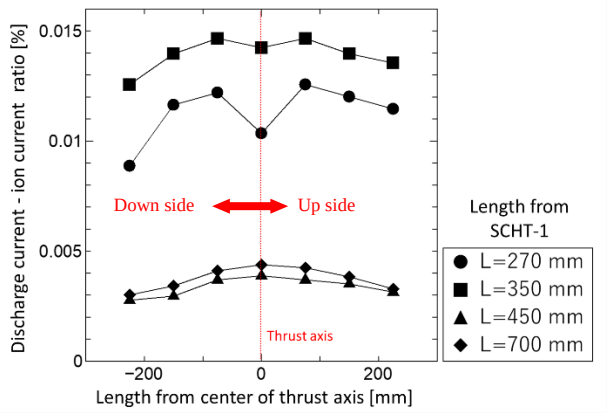

Figure 8. Vertical characteristics of discharge current to ion current ratio.

IV.Conclusions

The micro CHT named "SCHT-1" was developed, and the diverging shape of plume was measured. It is considered that the ion current near the center was small value at the short length, and plasma diffuses greatly to the outer circumference.

References

Periodicals

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