Development of Water Gridded Ion Thruster for Small Satellites: Toward On-Orbit Demonstration

Pale Blue

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I. Thruster

Water as a propellant has many advantages and does not require a pressure vessel for storage. Its high safety level can reduce development cost and time. It is also a resource tightly tied to human spaceflight and found in-situ in the upcoming moon missions.

Stored in its liquid state in our thrusters, it is then vaporized at room temperature and low pressure. The resulted steam is then injected in the discharge chambers where it is transformed into plasma. Plasma generation is achieved through flight-proven microwave discharge using Electron Cyclotron Resonance.

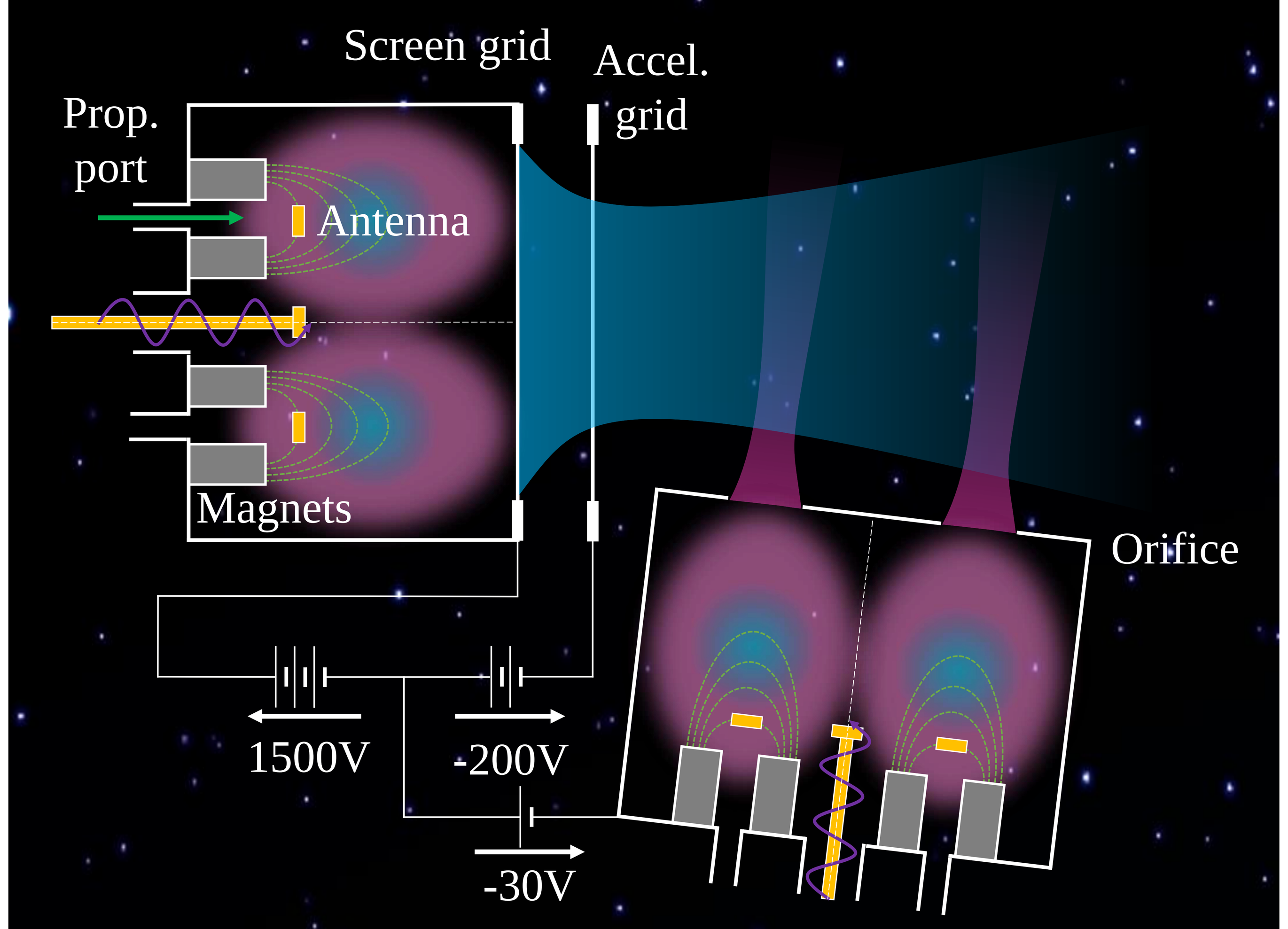
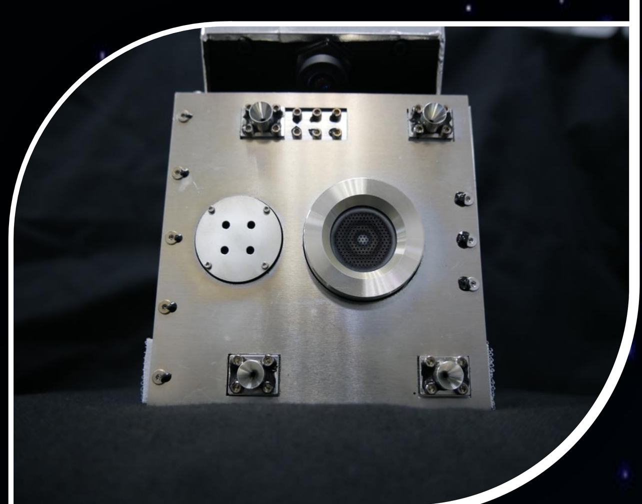


Figure 1 : Schematic of the thruster head, consisting of an Ion Source and a Neutralizer

Figure 2 : Integrated system with a camera on board. The thruster size is 1.5U with 2.2 kg of wet mass without the camera. On the right is the ion source and on the left is the neutralizer



II. Mechanical testing

The thruster was on board RAISE-3 satellite and launched on Epsilon #6. Despite the launch failure, the thruster has fully passed random, sine, and shock tests.

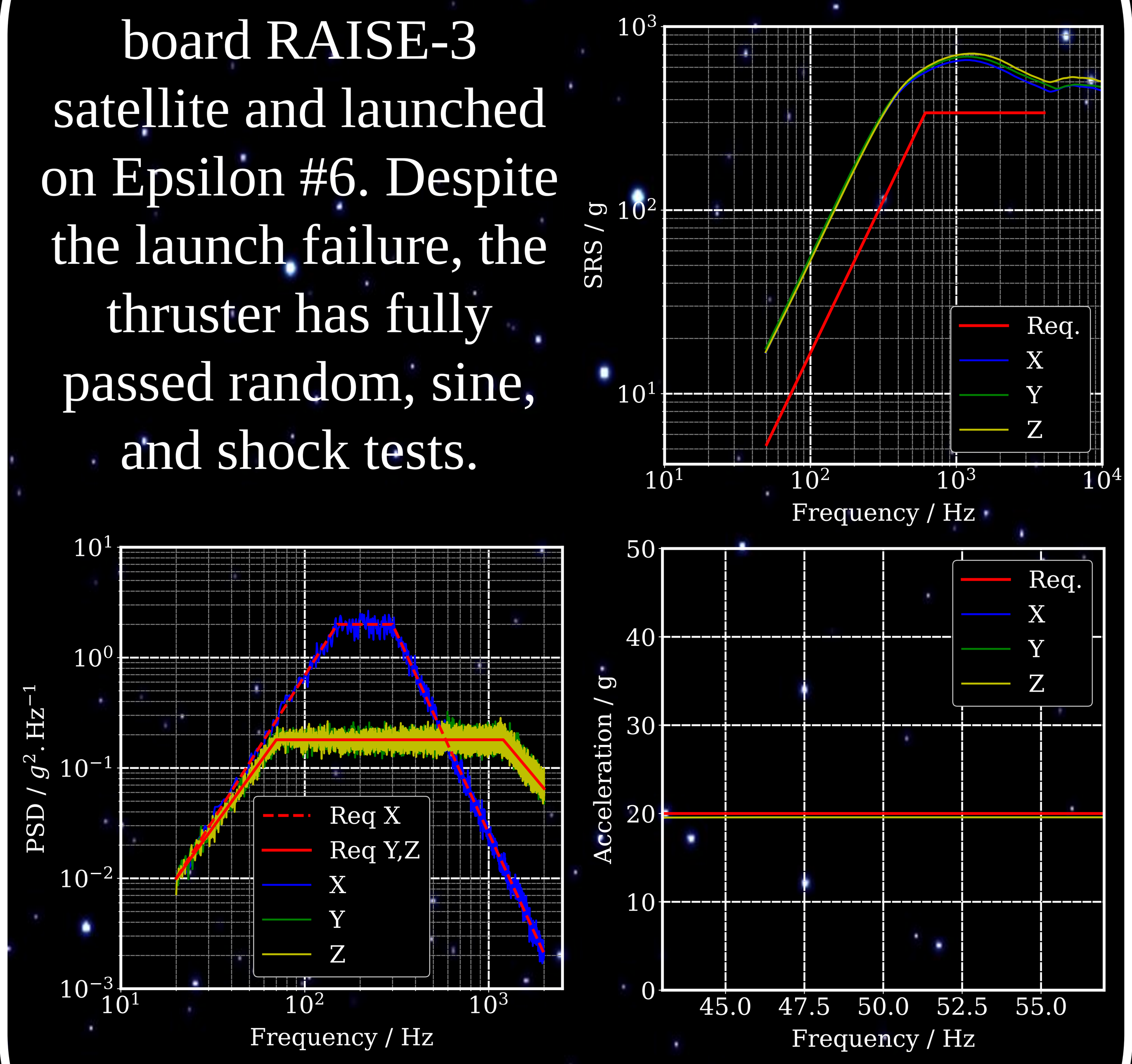


Figure 3 : Random, Sine, and Shock testing profiles

III. Thermal testing

In addition to mechanical tests, the thruster endured and successfully passed TVAC.

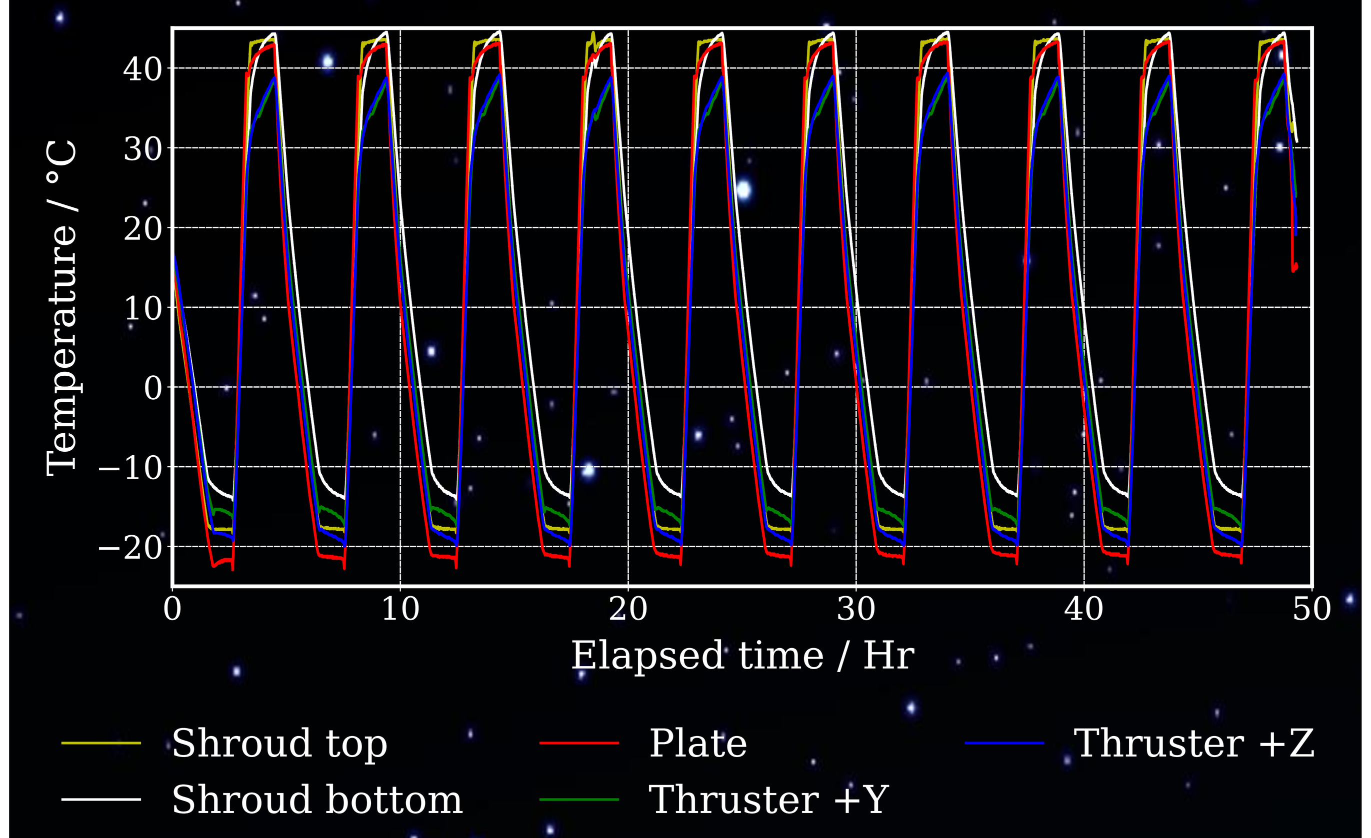


Figure 4 : TVAC temperature profiles. 10 cycles of 5hrs, from -20 °C to +45 °C

Figure 5 : Picture of the thruster in the TVAC chamber at Nagoya University

IV. Scale-up

Originally, the operating point of the current model of water ion thruster has been fine-tuned to match the market's need of low-power propulsion systems for small satellites. For this reason, the total power consumption was kept under 30W.

However, the power density of small satellites and the growing market share of over 50 kg-class satellites allows for a higher power consumption and a better performance of the thruster.

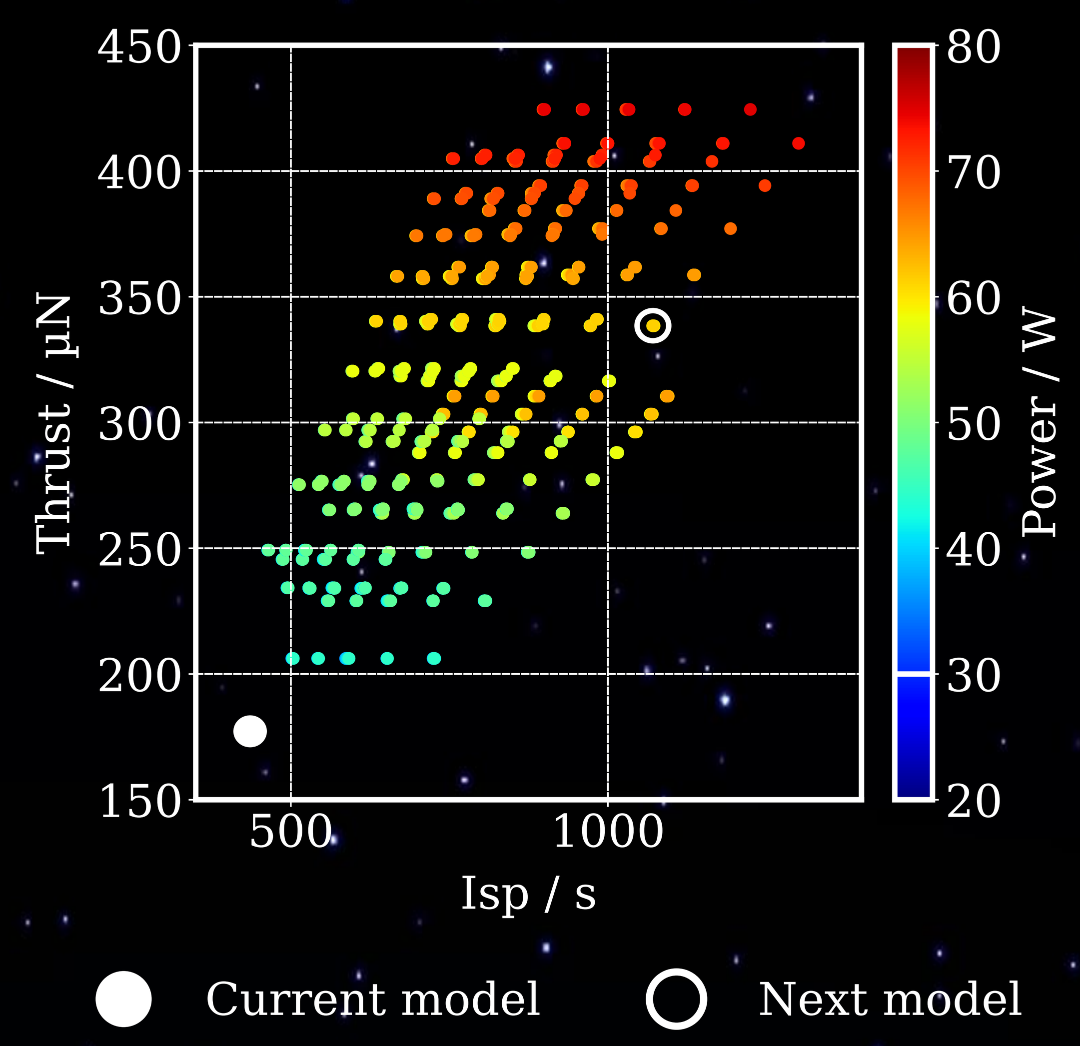


Figure 6 : Performance map of the developed water ion thruster. The current model and the next model operating points are highlighted

To match the new operating point, R&D has been conducted to successfully build a microwave power unit with higher output and efficiency.

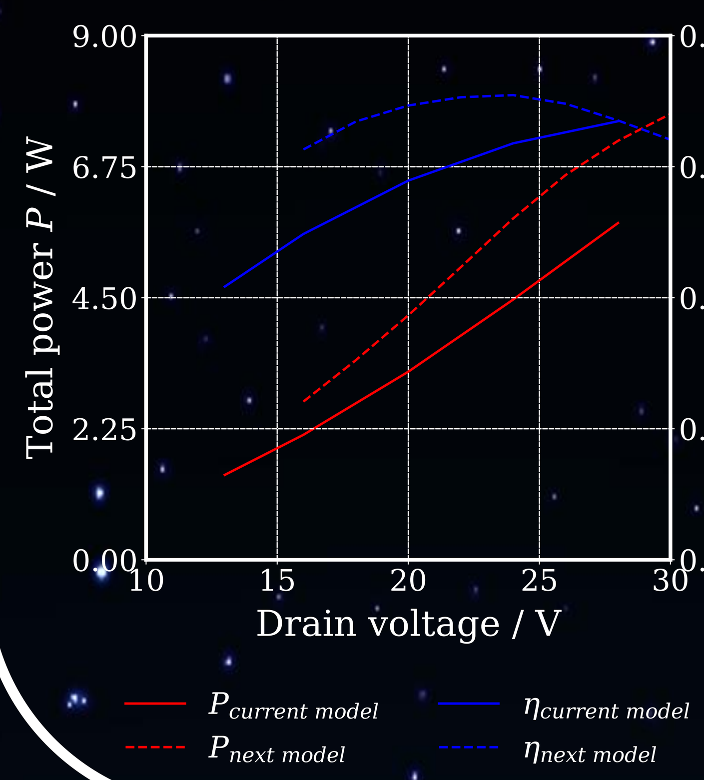


Figure 7 : Microwave power supply performance improvement

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