Applied Ion Systems

AIS-TR-019

AIS-EPPT1 Micro Pulsed Plasma Thruster V2

Ignition Test 3 - 10/18/2020

Testing Report and Summary

Michael Bretti – 10/27/2020

I. TEST PARAMETERS

- **System:** AIS-EPPT1 Micro Pulsed Plasma Thruster V2
- **Fuel:** Teflon
- **Maximum Chamber Pressure During Testing:** 1.5 x 10^-5 Torr
- **Testing Status:** COMPLETE
  - **Phase I:** Fueling – NOT REQUIRED
  - **Phase II:** Ignition – UNSUCCESFUL

II. OVERVIEW

This test represents the third and final ignition test of the new experimental AIS-EPPT1 micro pulsed plasma thruster for Cubesats and PocketQubes.

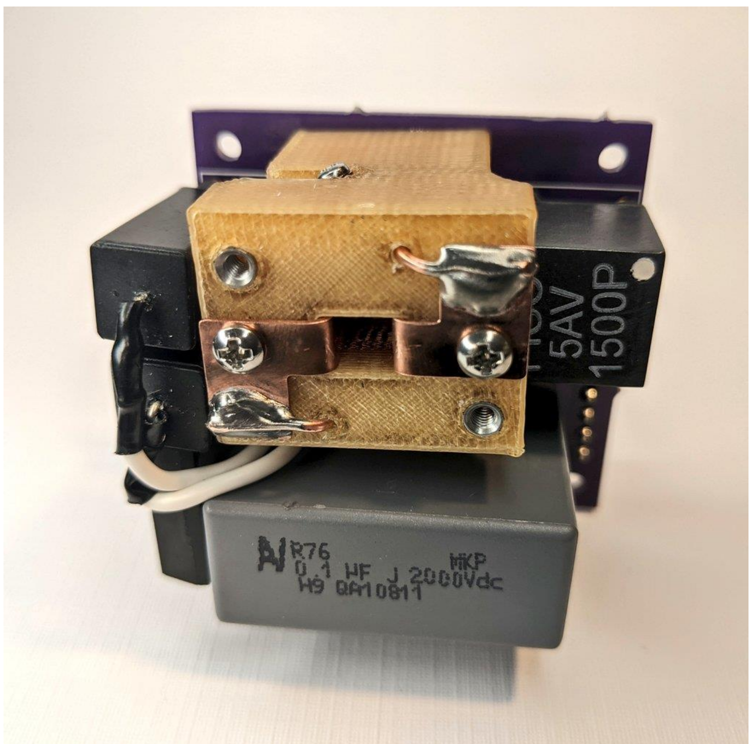

FIGURE 1: *Completed AIS-EPPT1 V2 thruster assembly*

The test aimed to qualify new changes to the thruster with the V2 housing design based on prior testing results, incorporating features to improve thruster reliability during operation. A new 3D printed housing was designed and implemented for the test.

III. THRUSTER DESIGN CHANGES OVERVIEW

Prior testing validated the improvement to ignition utilizing anode-side triggering to increase the ignition arc intensity. The thruster was redesigned with several changes in mind to improve ignition reliability over extended periods of operation, with the goal to achieve stable operation at 3Hz. The major change focused around redesign of the housing, which includes narrower anode-cathode spacing of 0.1825” from 0.25”, a longer and narrower discharge chamber, square fuel bar and fuel feed bore, angled igniter for anode-side triggering, sharpened igniter pin, and embedded igniter connection. In addition, extra mounting holes were included in the top of the housing for future experimental work into a pulsed plasma ion thruster conversion (PPIT).

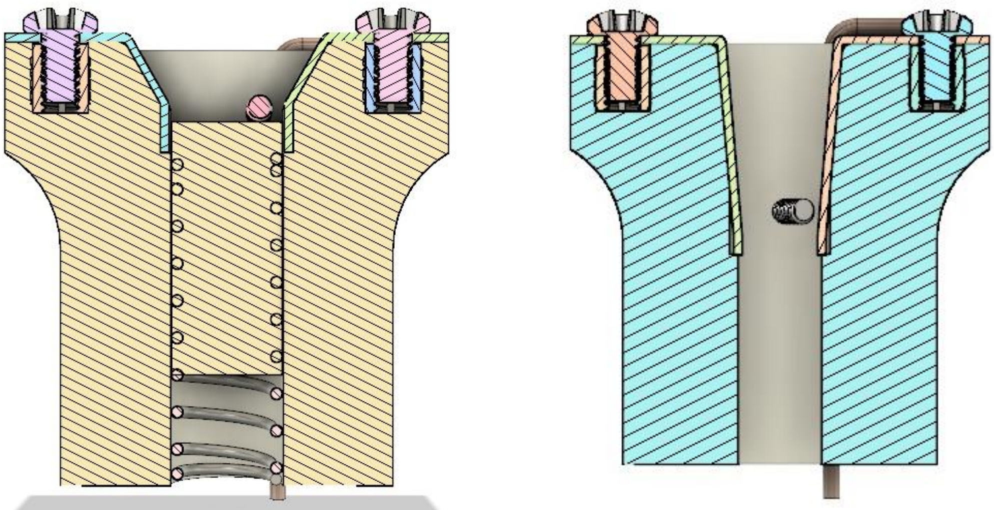

FIGURE 2: *EPPT1 cross-section comparison of the V1 housing design (LEFT) and V2 housing design (RIGHT)*

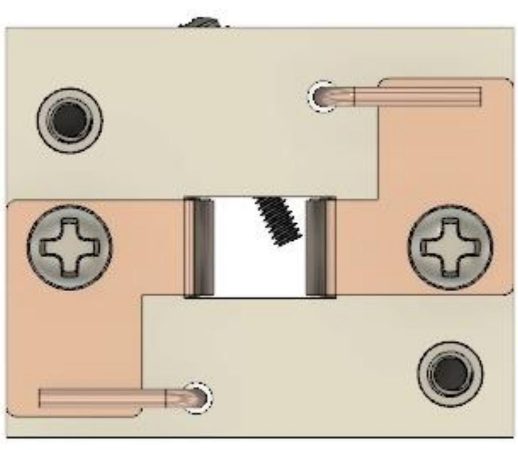

FIGURE 3: *EPPT1 V2 design top-view showing angled ignition pin for anode-side triggering, and additional mounting holes for future experimental work*

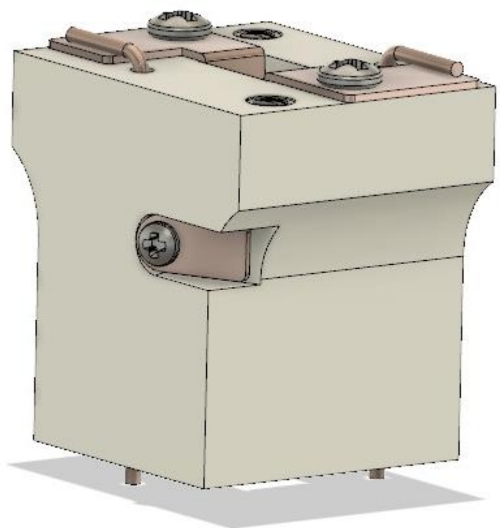

FIGURE 4: *EPPT1 V2 side view with embedded trigger connection slot in the side of the 3D printed housing*

IV. IGNITION TEST SETUP

After final assembly and cleaning of the thruster, the thruster was mounted to the same flat PEEK baseplate used in the prior ignition tests, and loaded into the chamber to keep the thruster oriented properly during testing, as well as insulated away from the conductive metal vacuum chamber walls. Teflon coated wire was used to secure the thruster to the baseplate, tied through the corner mounting holes on the thruster board and wrapped around the baseplate. The thruster was then loaded into the chamber, positioned in clear view of the 6” conflat viewport, and wired for power, enable, and trigger pulse control. An external adjustable DC power supply and function generator was used to provide power and trigger control to the thruster.

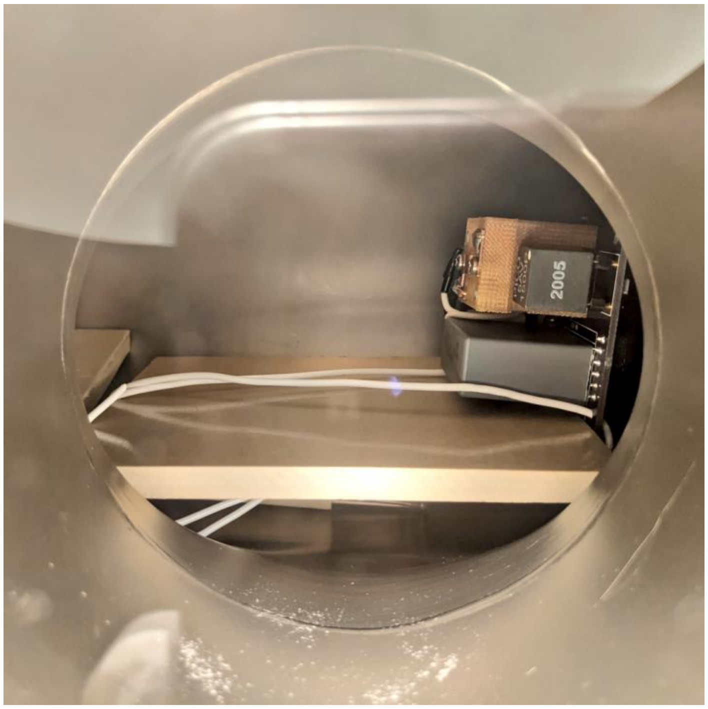

FIGURE 5: *EPPT1 mounted on the PEEK baseplate inside the vacuum chamber, tied down to the baseplate with Teflon coated wires.*

V. TEST PHASE II – IGNITION

The chamber was evacuated to a pressure of 1.5x10^-5 Torr before starting up the thruster. Thruster power was turned on, and slowly raised to near peak voltage at 1.4kV. Triggering was turned on and brought up to full signal voltage, starting at a low repetition rate of less than 1Hz. No successful ignition pulses were observed, with only a couple of spurious weak plasma emissions. Soon after the start of the test, shorting failure occurred inside the discharge chamber, forcing the test to end early. As a result, no video or data was collected during the test.

VI. POST-TEST ANALYSIS

Upon inspection of the thruster, it was discovered that the 3D printed Ultem housing had charred between the anode, igniter, and cathode, resulting in shorting failure of the thruster.

VII. CONCLUSION

The third ignition test of the AIS-EPPT1 micro pulsed plasma thruster has been completed. Unfortunately, the anticipated design changes resulted in the worst performance of the thruster yet, with near immediate failure after the start of the test.

Throughout the testing and development campaign of the EPPT1, it has become obvious that for this particular application, 3D printing the housing has plagued thruster operation, predominantly with arcing through the layers and voids, spurious flashovers due to trapped gases, and eventual shorting due to charring of the plastic. While 3D printing has been successfully demonstrated without issue on the AIS-ILIS1 ionic liquid electrospray thruster so far, performance in the application for PPTs has fallen short.

However, even solving this issue with FDM printing, or going with an SLA resin that has minimal outgassing, there is still a major, fundamental limiting factor that goes beyond just getting PPTs to operate reliably at this level. Even if the thruster worked perfectly, sub-Joule PPTs are not competitive enough in terms of performance when compared to other options at this scale, suffering from significantly lower thrust/power and ISP with other contenders such as VATs and ILIS.

As a result of testing to date, and reviewing the field as a whole, along with implications of the limitations of this current design and technology, the AIS-EPPT1 micro pulsed plasma thruster is being officially retired. However, significant progress with improvements to the electronics have been made, paving a way for new micro PPT and general pulsed plasma source developments at AIS.