Open Source Micro Propulsion Development for Small Satellites

AIS-gPPT Series Pulsed Plasma Thrusters

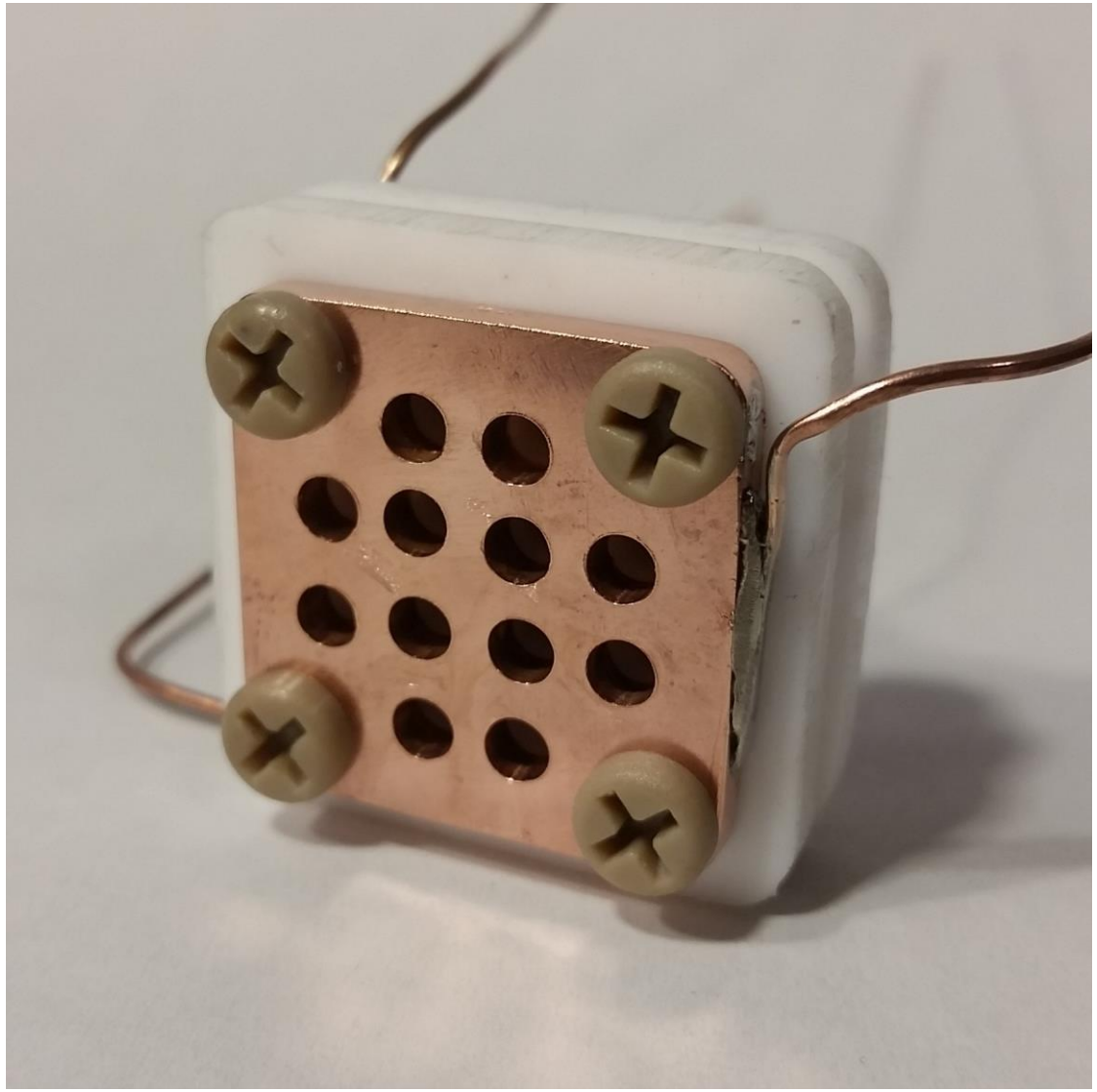
Applied Ion Systems

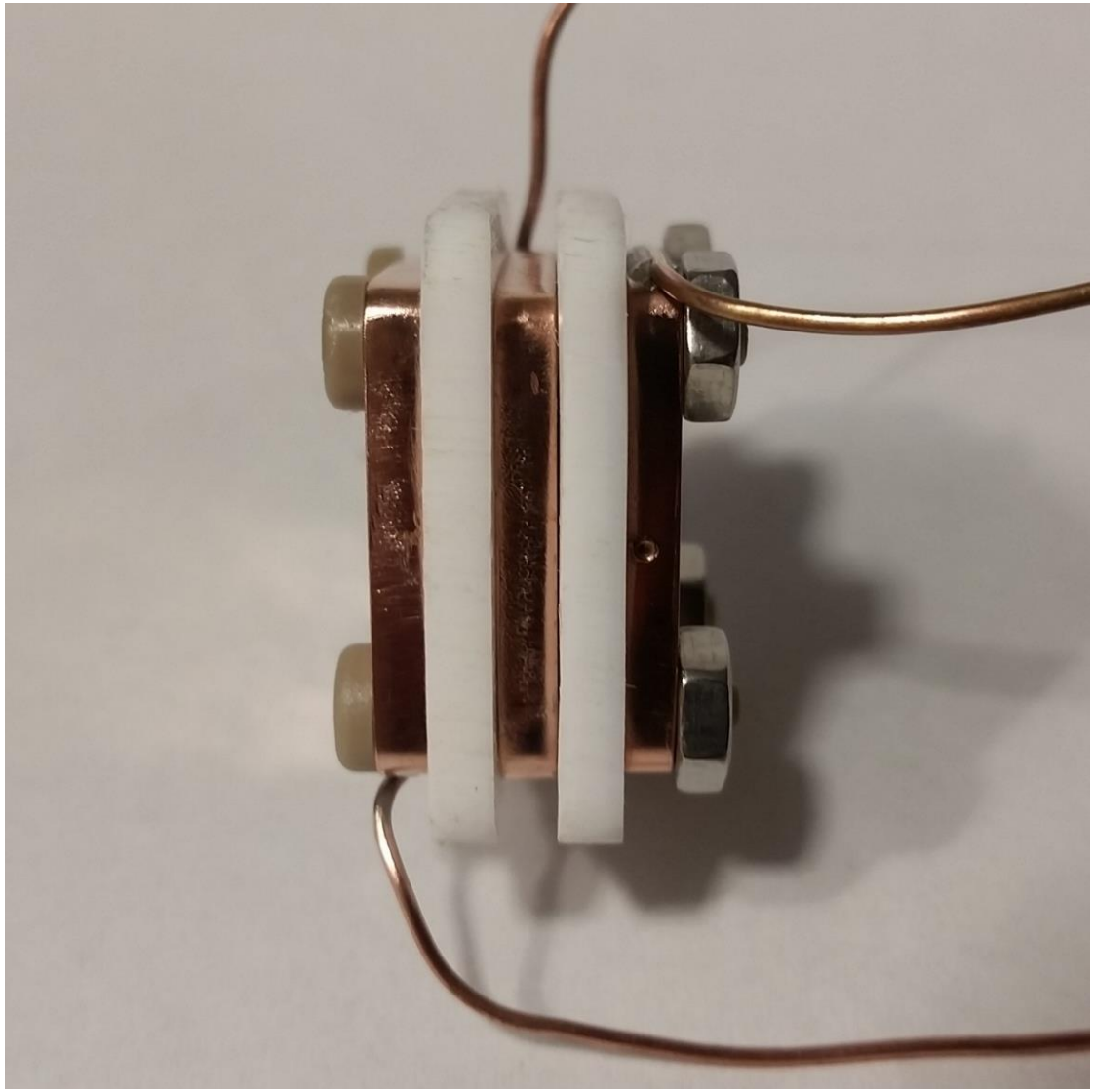
Michael Bretti

OVERVIEW

- First and only fully independent open-source home-based advanced electric propulsion R&D program
- Provide substantial technical resources for the open source/open space community through ***Applied Ion Systems***
  - cad, electronics, build pictures, specs, simulations, walkthroughs, test reports, tutorials, etc.
- Reducing the barrier of entry in the field through low-cost DIY open-source approach and engaging the community
  - unconventional approach from current academia and industry efforts
  - full build details, live propulsion testing (recent)
- Ultra low cost, simple to build, miniaturized, fully deployable EP modules
  - enthusiasts, start-ups, academic research, etc.

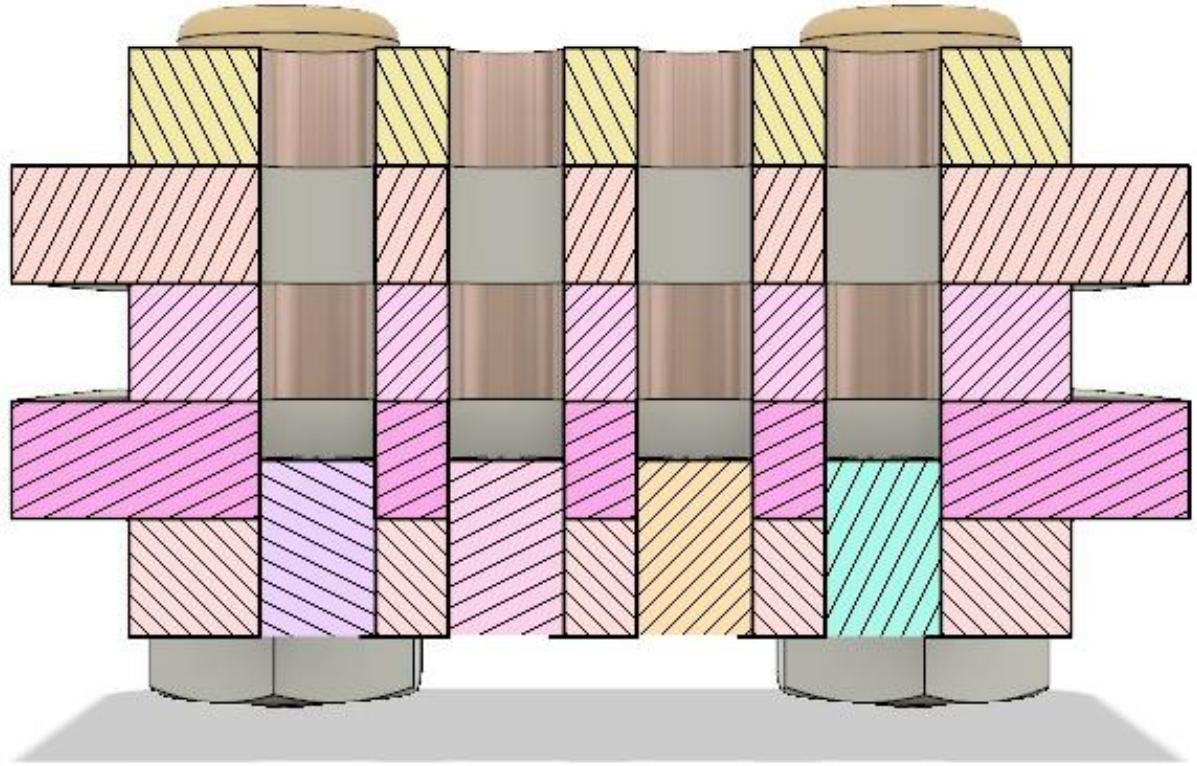
AIS-gPPT1 Gridded Pulsed Plasma Thruster



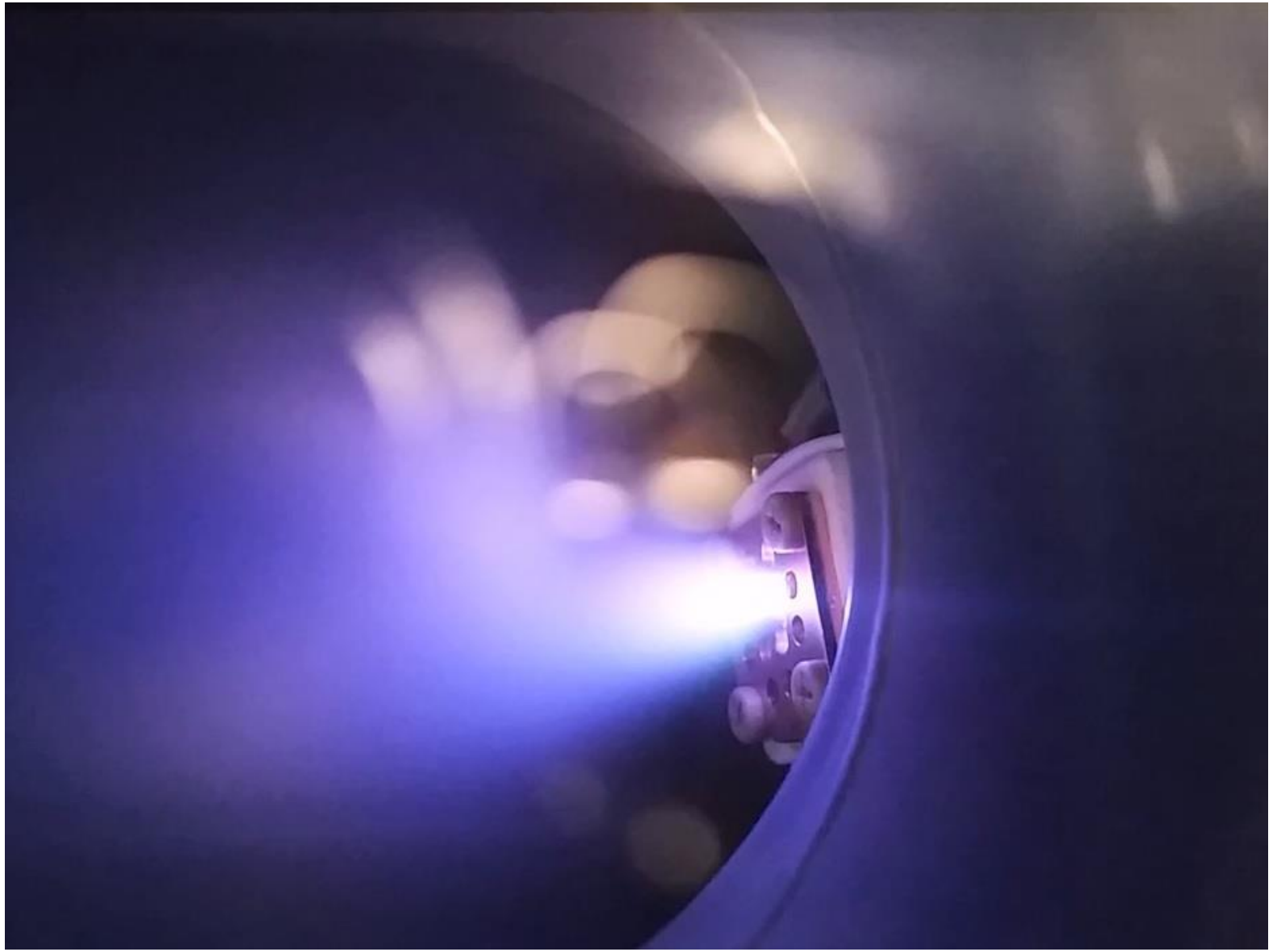


AIS-gPPT1 – Design Overview

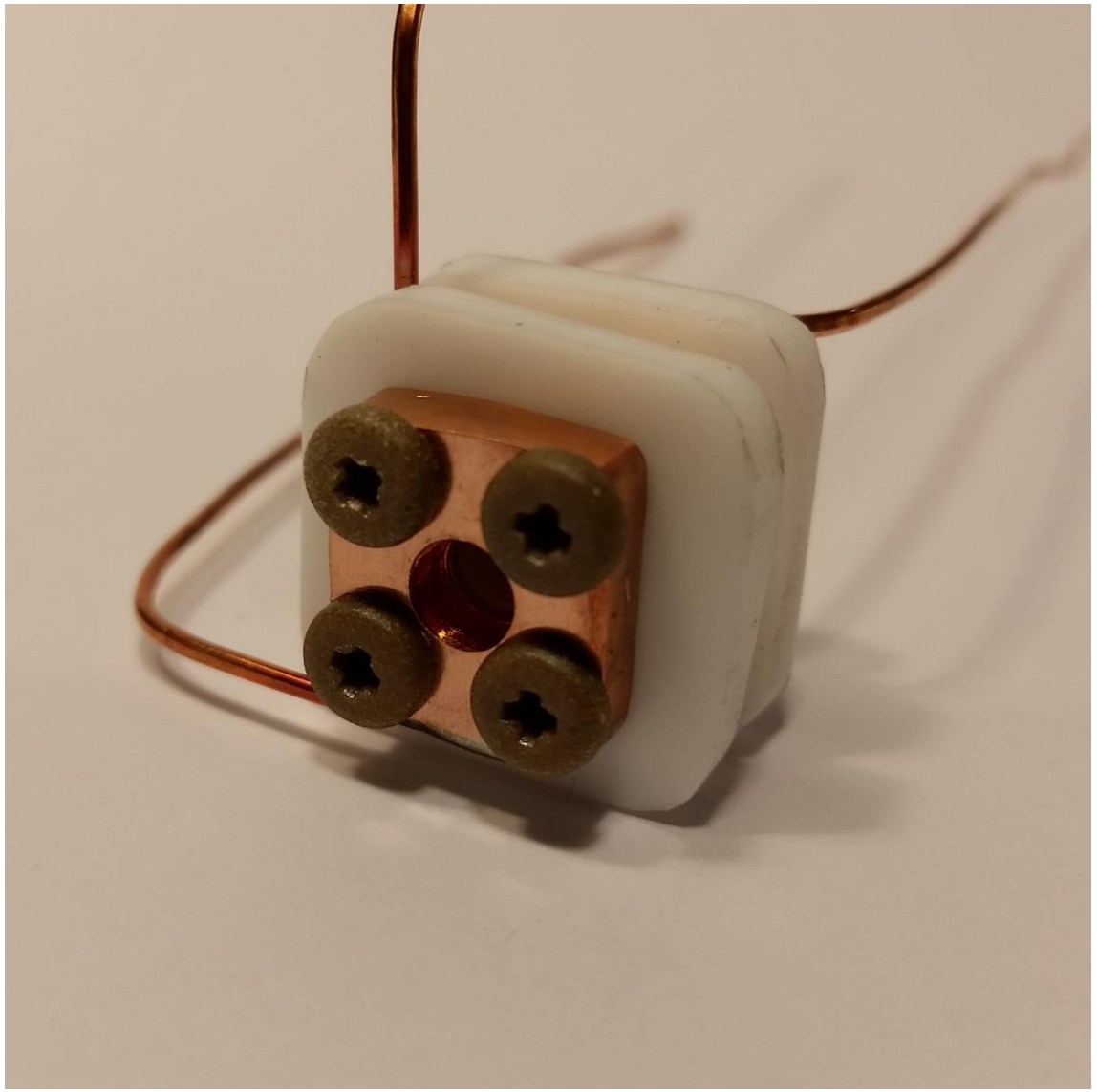
- Flat stacked plate geometry
- 32mm x 32mm x 16mm
- Grid of channels for extended lifetime
- Common materials (copper plate, Teflon plate, PEEK hardware)
- Low energy range operation (<5J)
- Electrothermal-mode PPT
- Top to bottom: anode, fuel, cathode, insulator, igniter

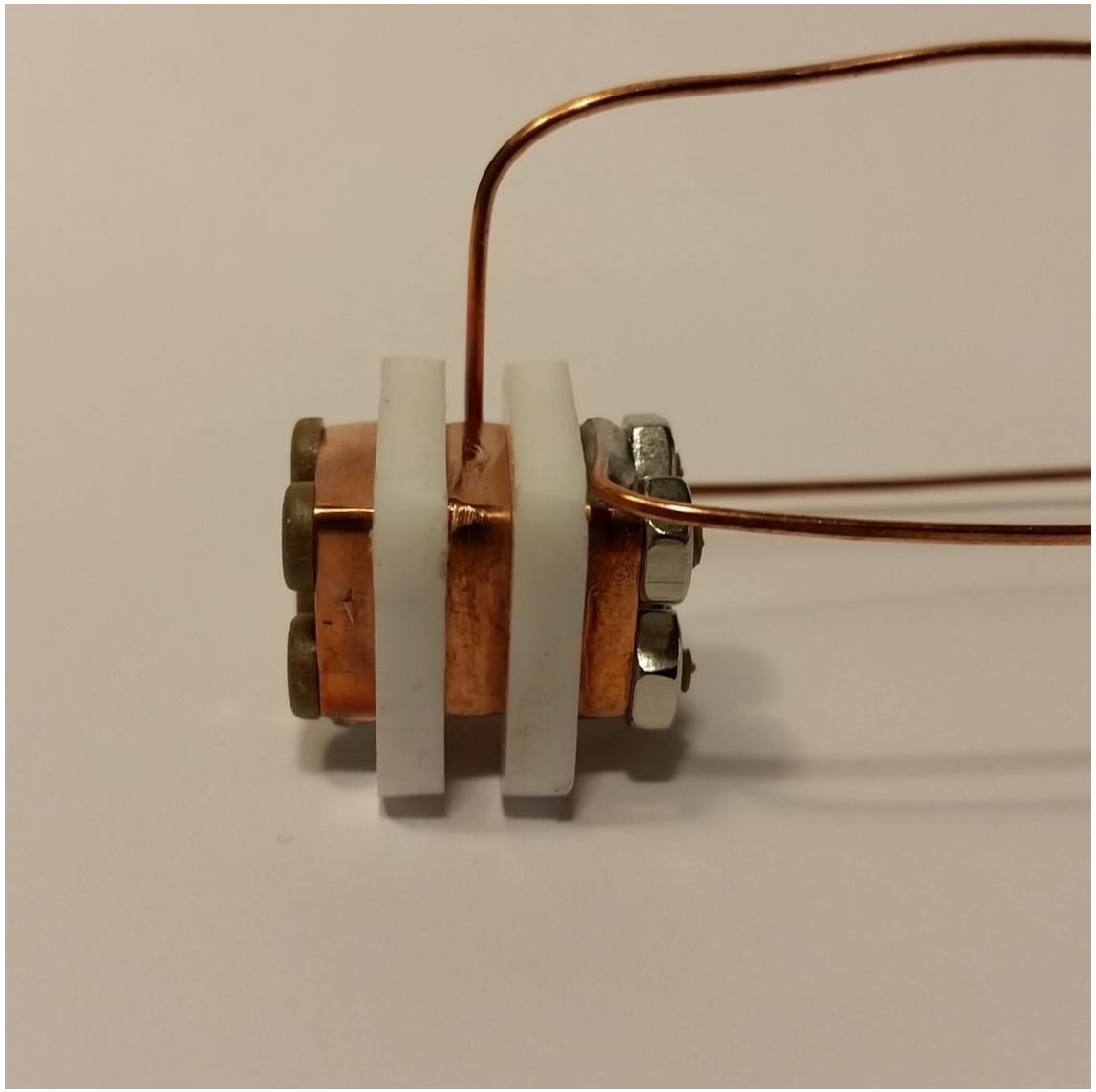


AIS-gPPT1 – High Vacuum Ignition Testing



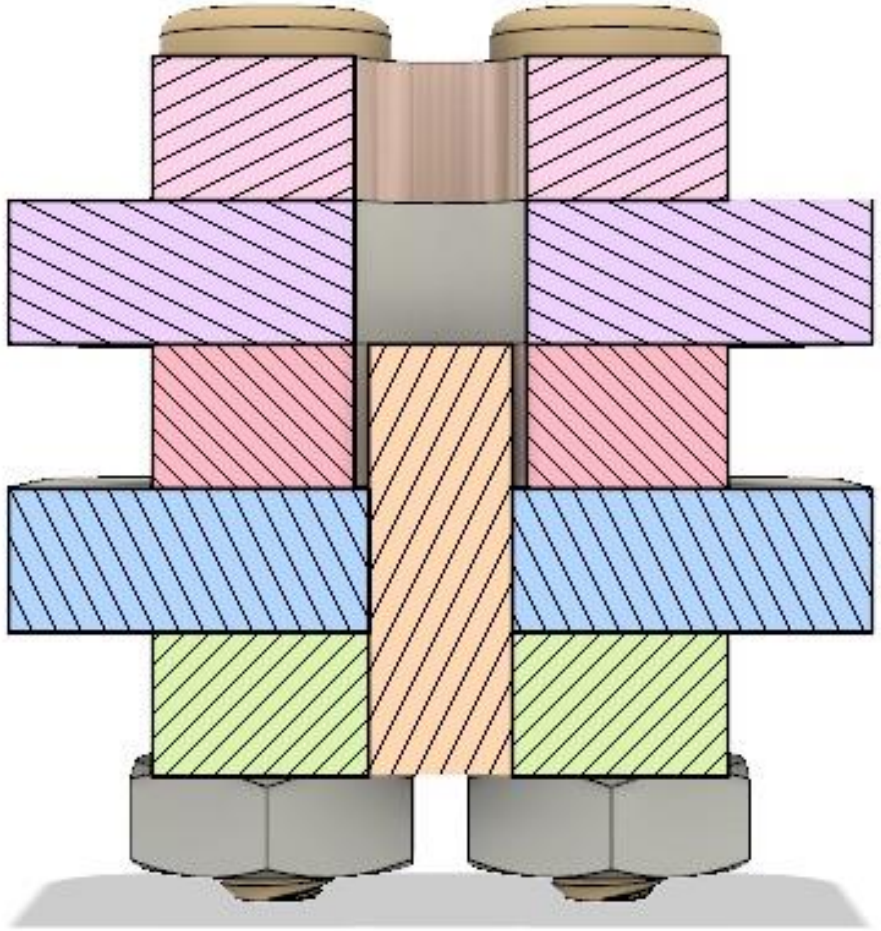
AIS-gPPT2-1C Gridded Pulsed Plasma Thruster



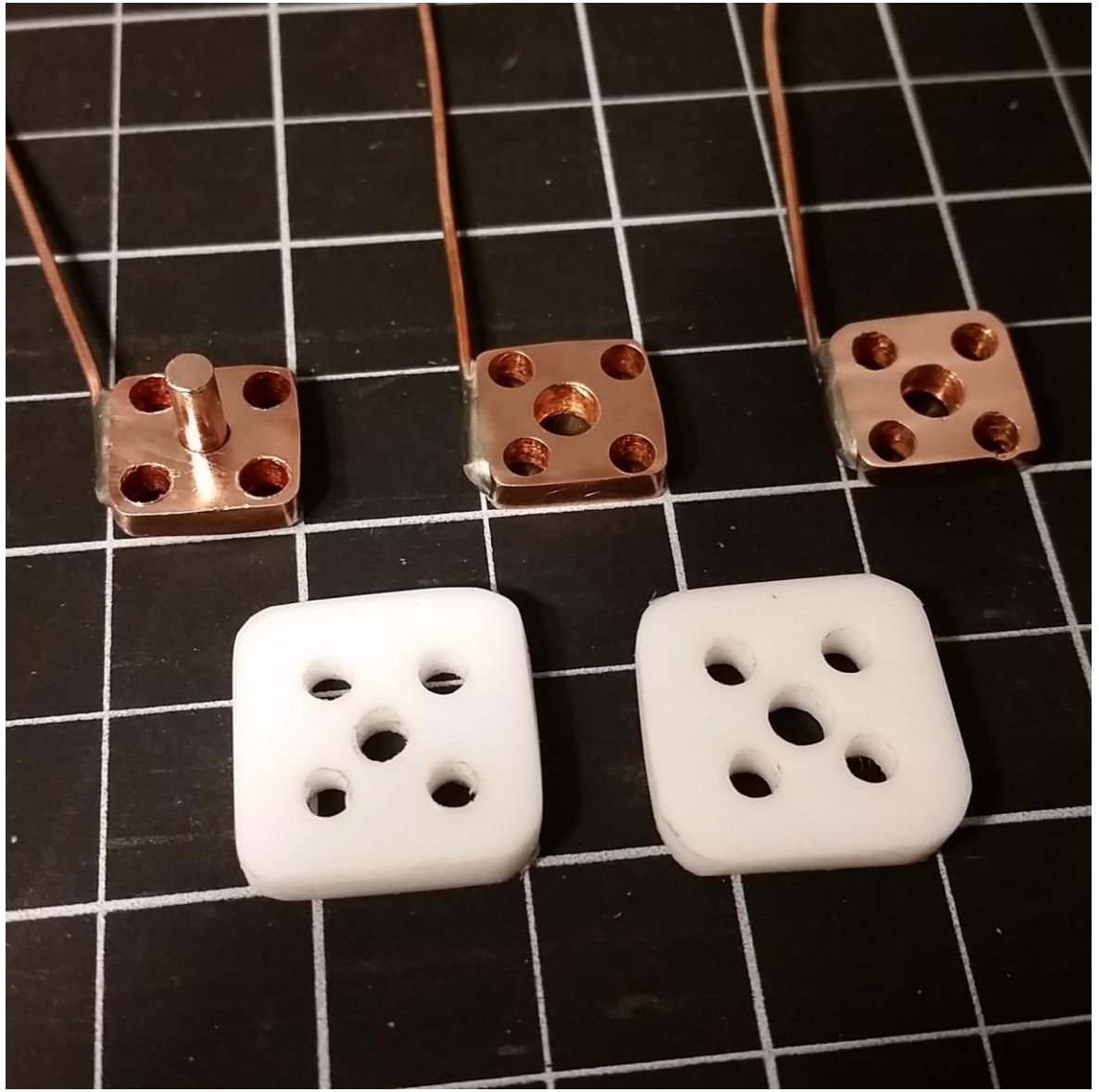


AIS-gPPT2-1C – Design Overview

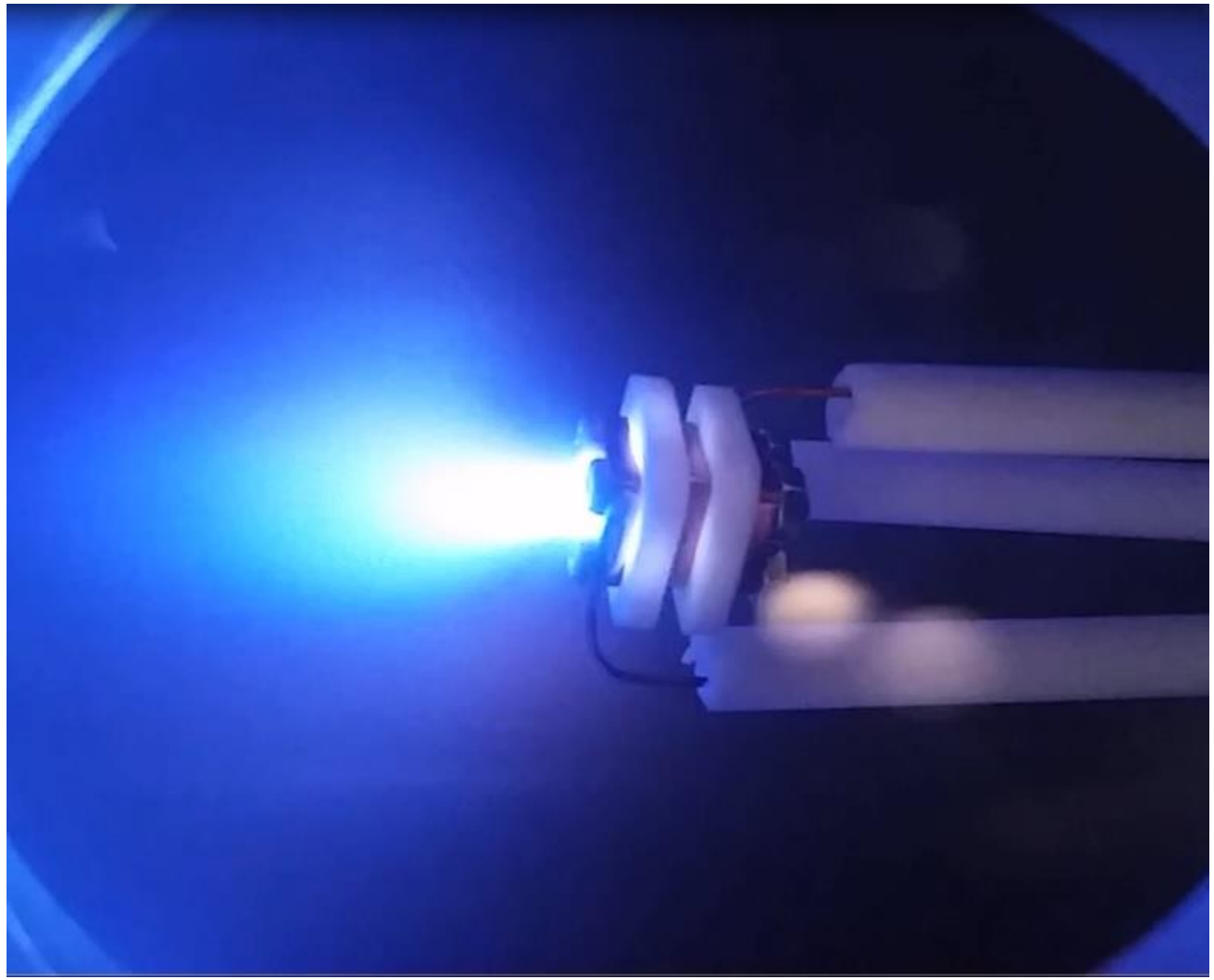
- Flat stacked plate geometry
- 19mm x 19mm x 16mm
- Sub-joule electrothermal PPT
- Single channel micro-PPT
- Modified ignition configuration
  - reverse igniter (center igniter bore with cathode pin)
  - reduced ignition spacing
- Top to bottom: anode, fuel, igniter, insulator, cathode



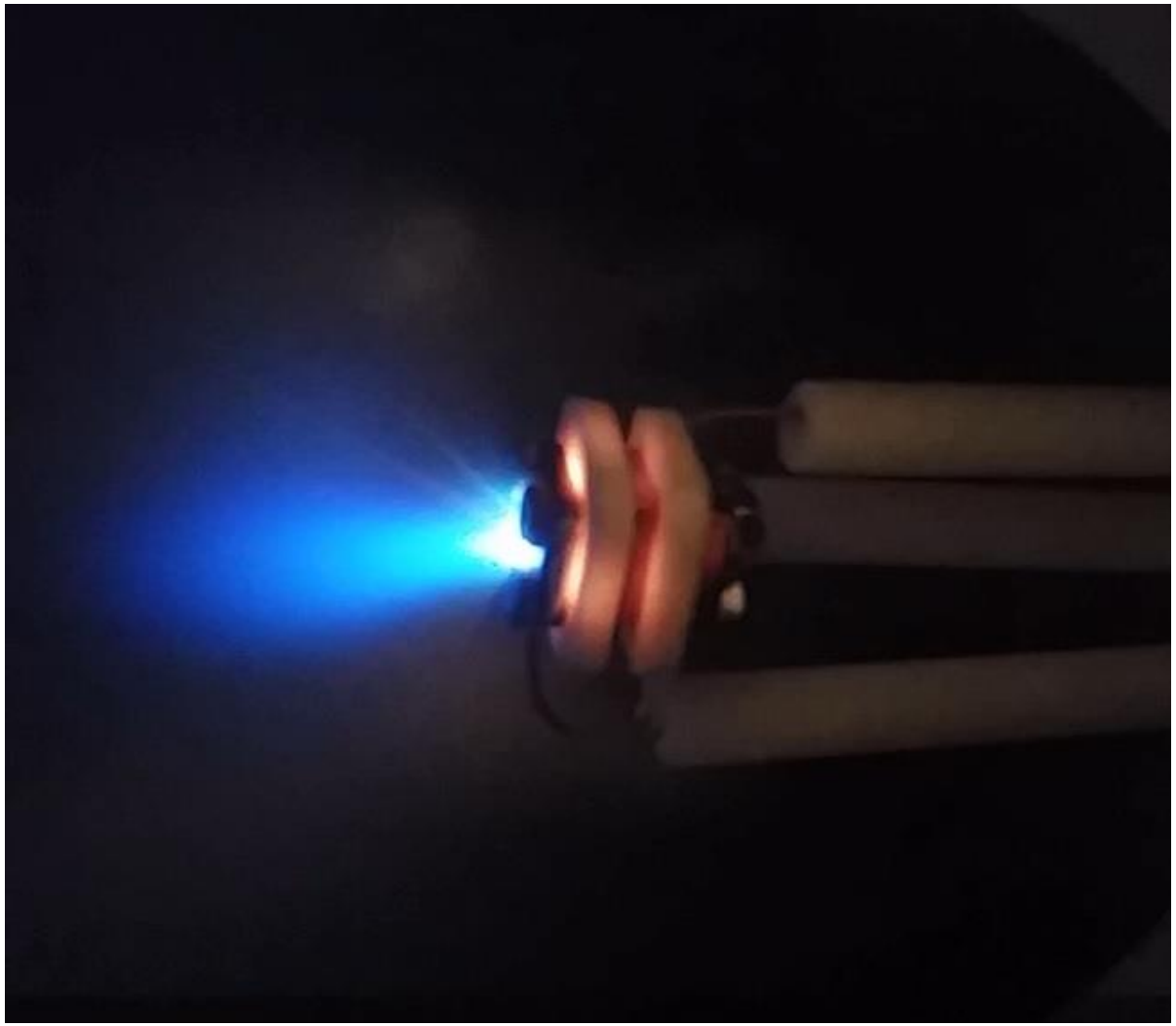
AIS-gPPT2-1C – Thruster Components



AIS-gPPT2-1C – High Vacuum Ignition Testing

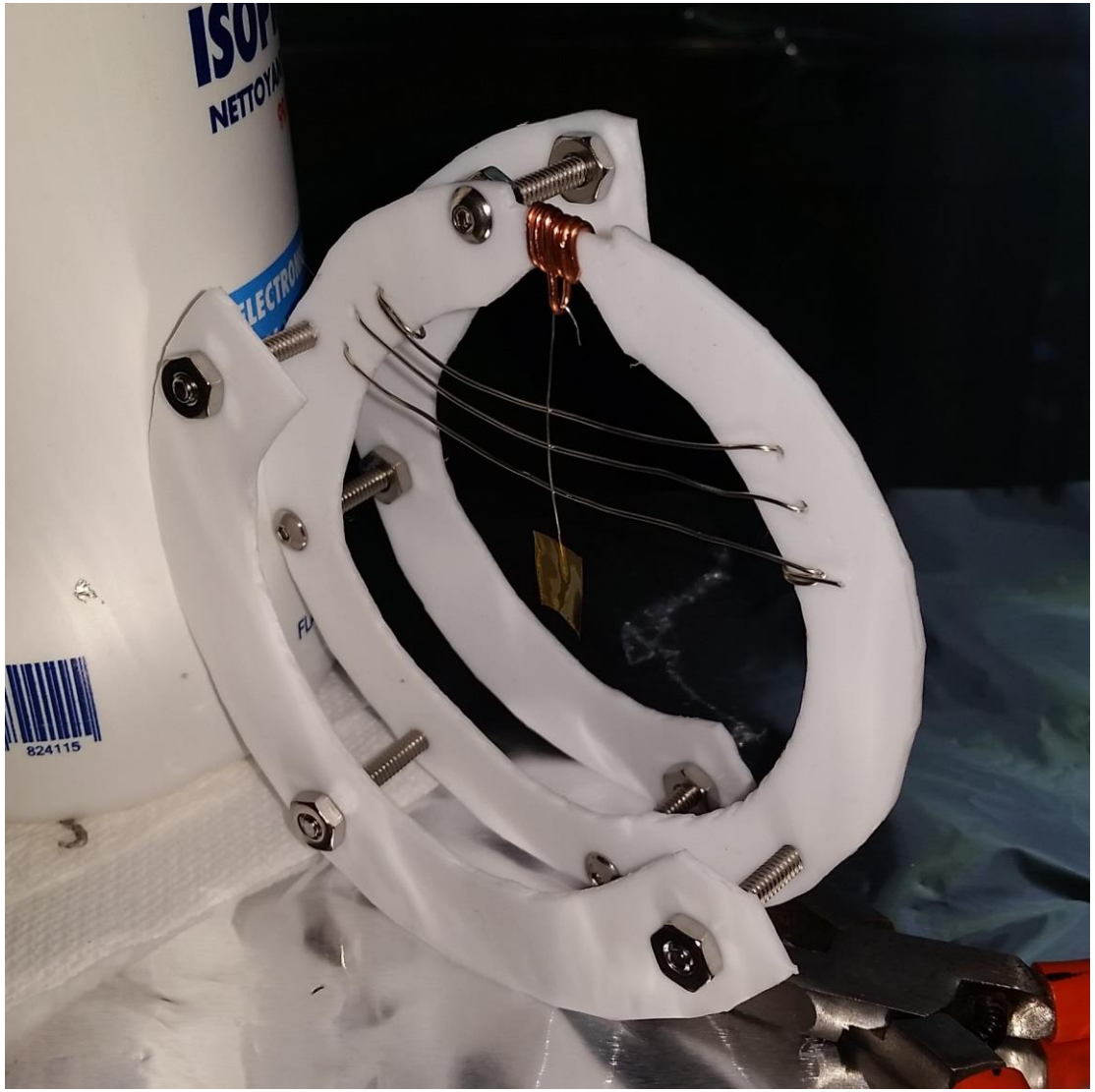


0.84J, 1Hz, 1300V

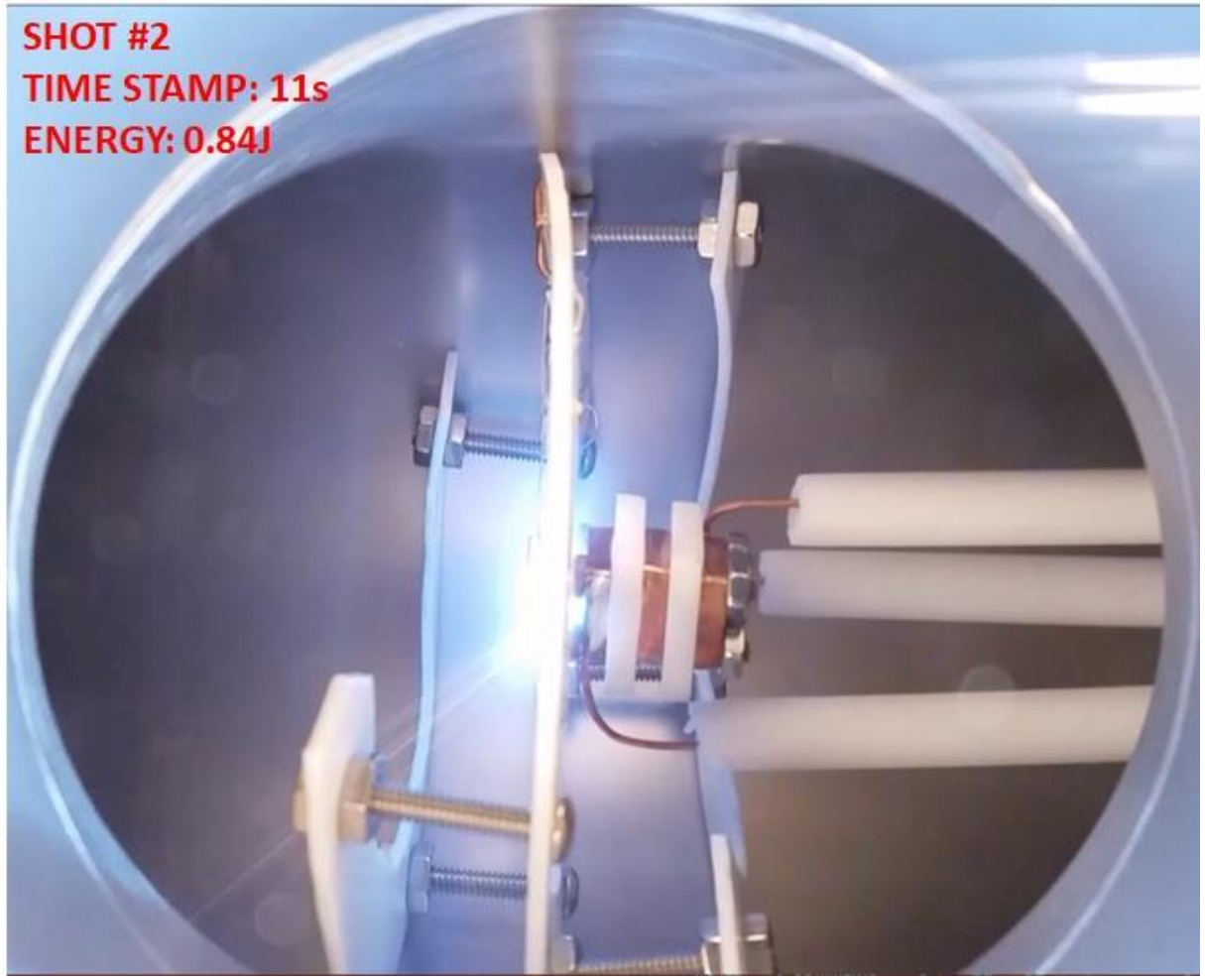


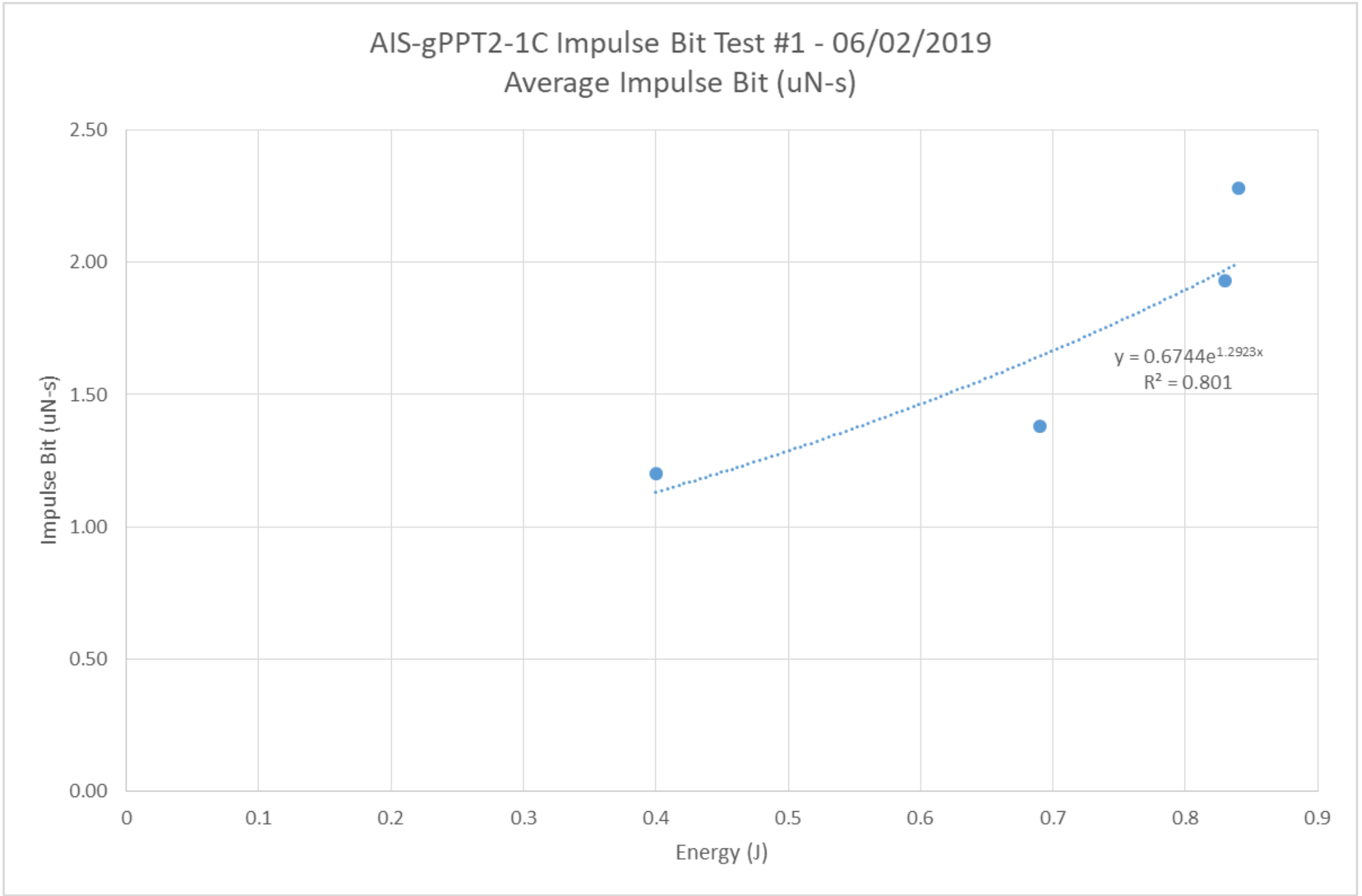
0.23J, 2Hz, 680V

AIS-gPPT2-1C – Impulse Bit Micro Pendulum



AIS-gPPT2-1C – Impulse Bit Testing

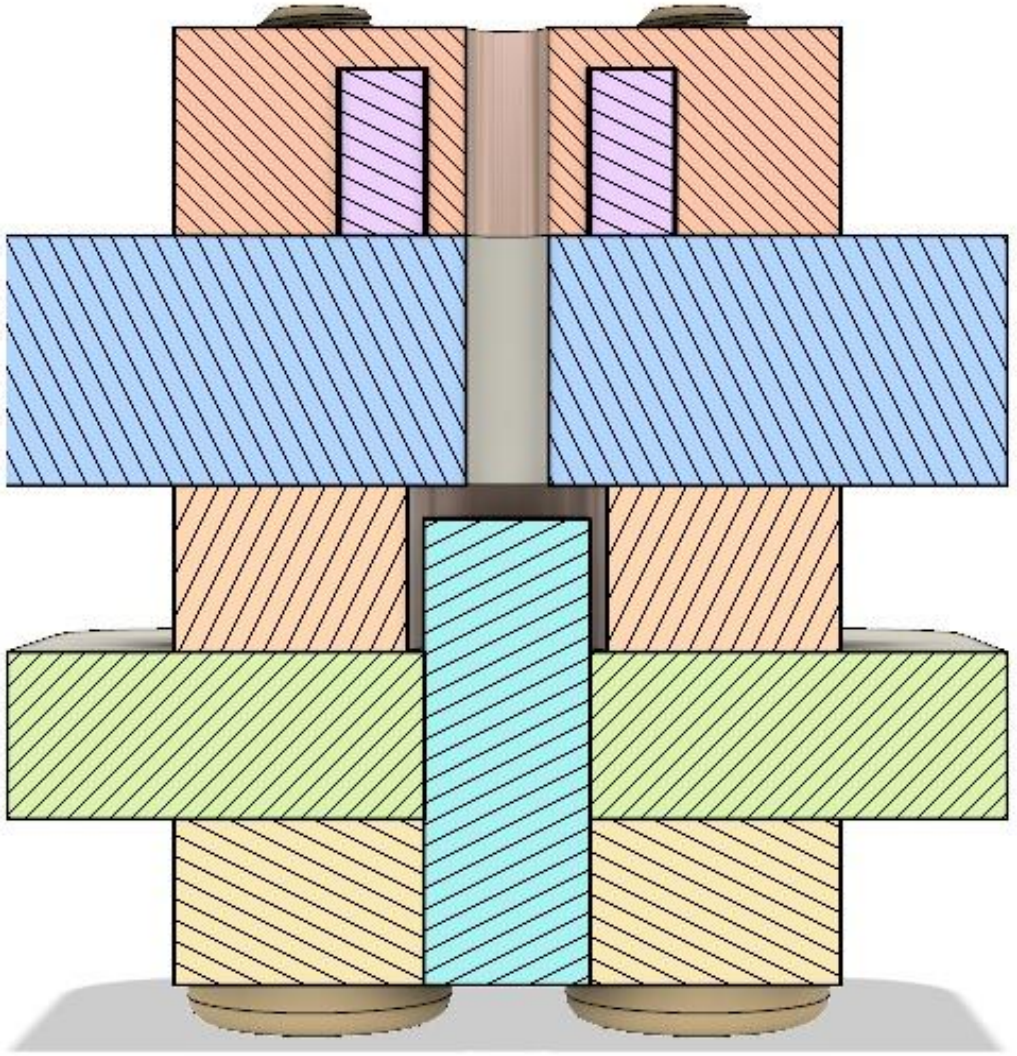



AIS-gPPT2-1C Impulse Bit Test #1 - 06/02/2019
Average Impulse Bit (uN-s)
Impulse Bit (uN-s)
2.50
2.00
1.50
1.00
0.50
0.00
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Energy (J)
y = 0.6744e1.2923x
R² = 0.801

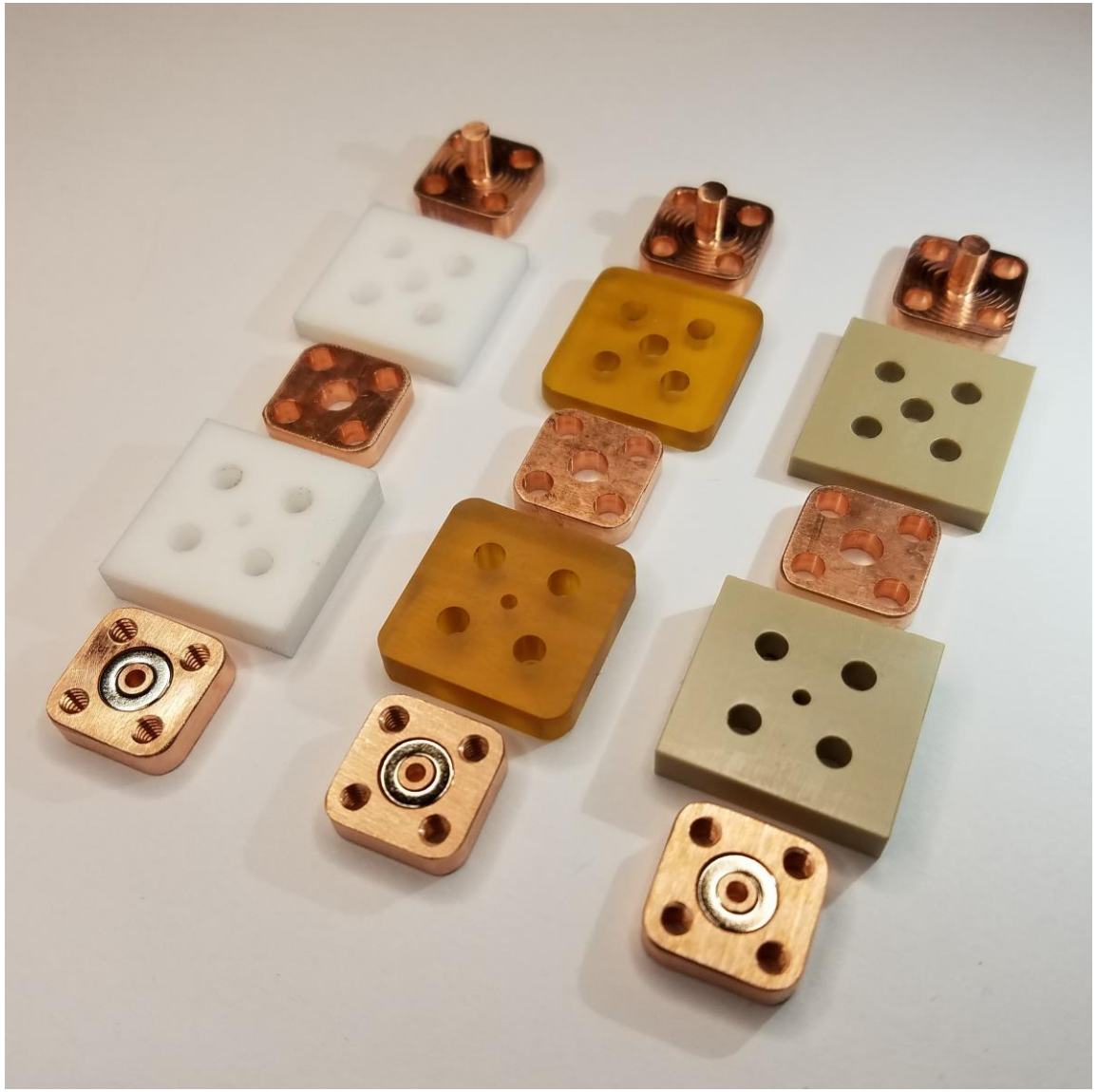
AIS-gPPT3-1C Gridded Pulsed Plasma Thruster

AIS-gPPT3-1C – Design Overview

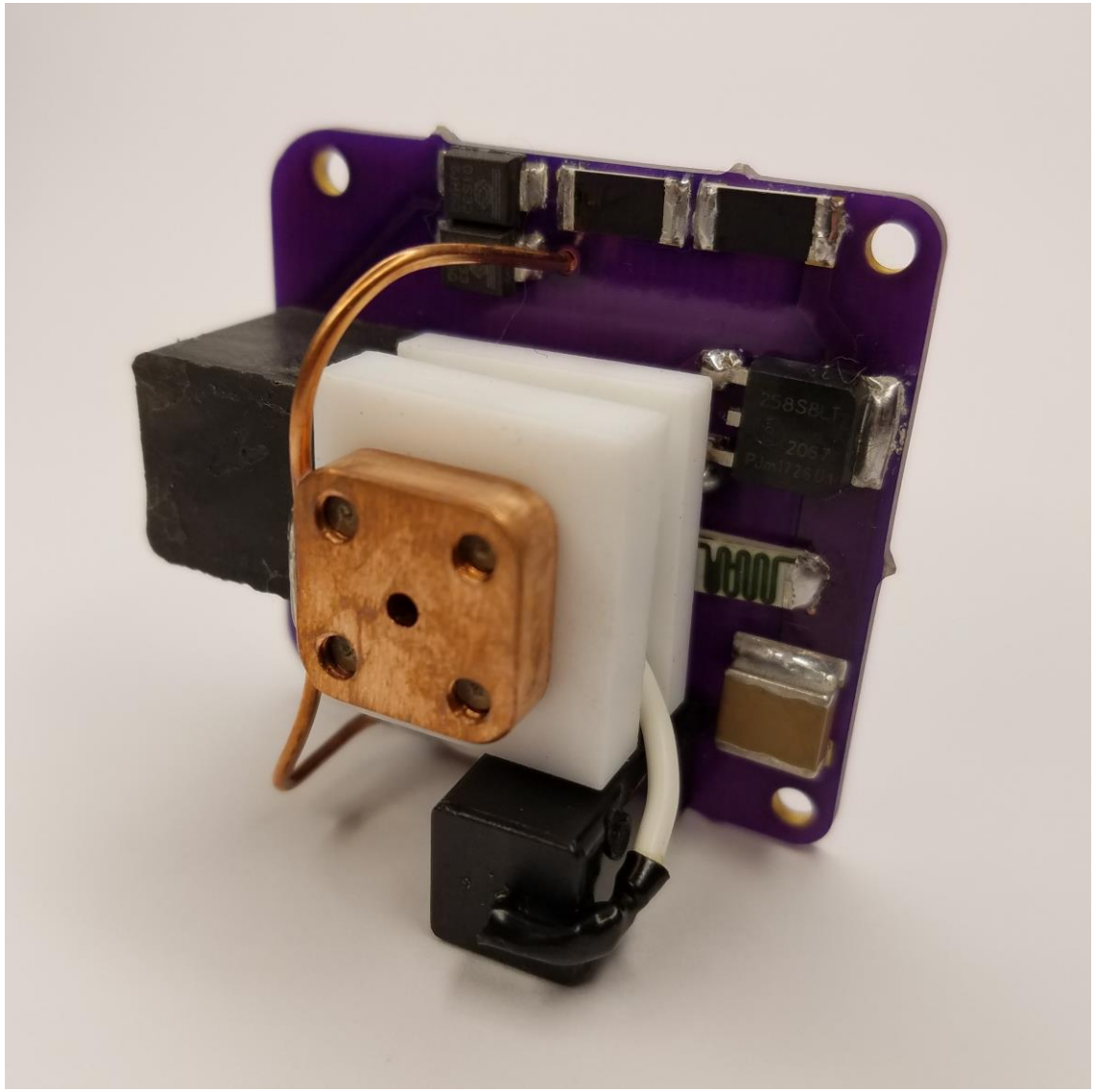
- Flat stacked plate geometry
- 19mm x 19mm x 18mm
- Sub-joule electrothermal PPT
- Optimization for reduced energy operation (<0.25J)
- Reduced fuel bore diameter and increased fuel bore length to improve lifetime
- Embedded N52 permanent magnet in anode to create magnetic nozzle
- New fuels (Ultem and PEEK) in addition to Teflon
- Tapped anode plate
- Direct integration with electronics module

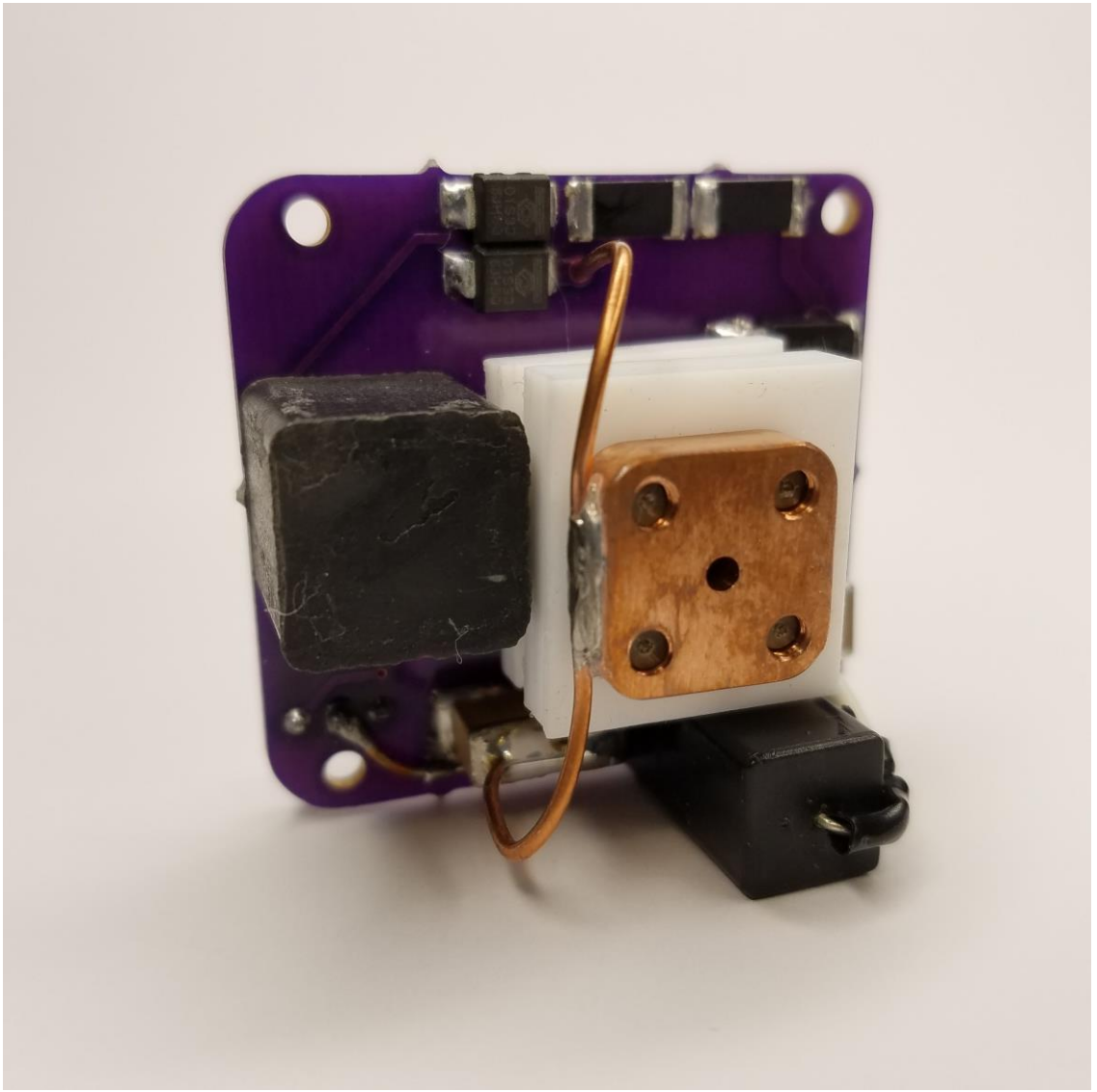


AIS-gPPT3-1C Thruster Components



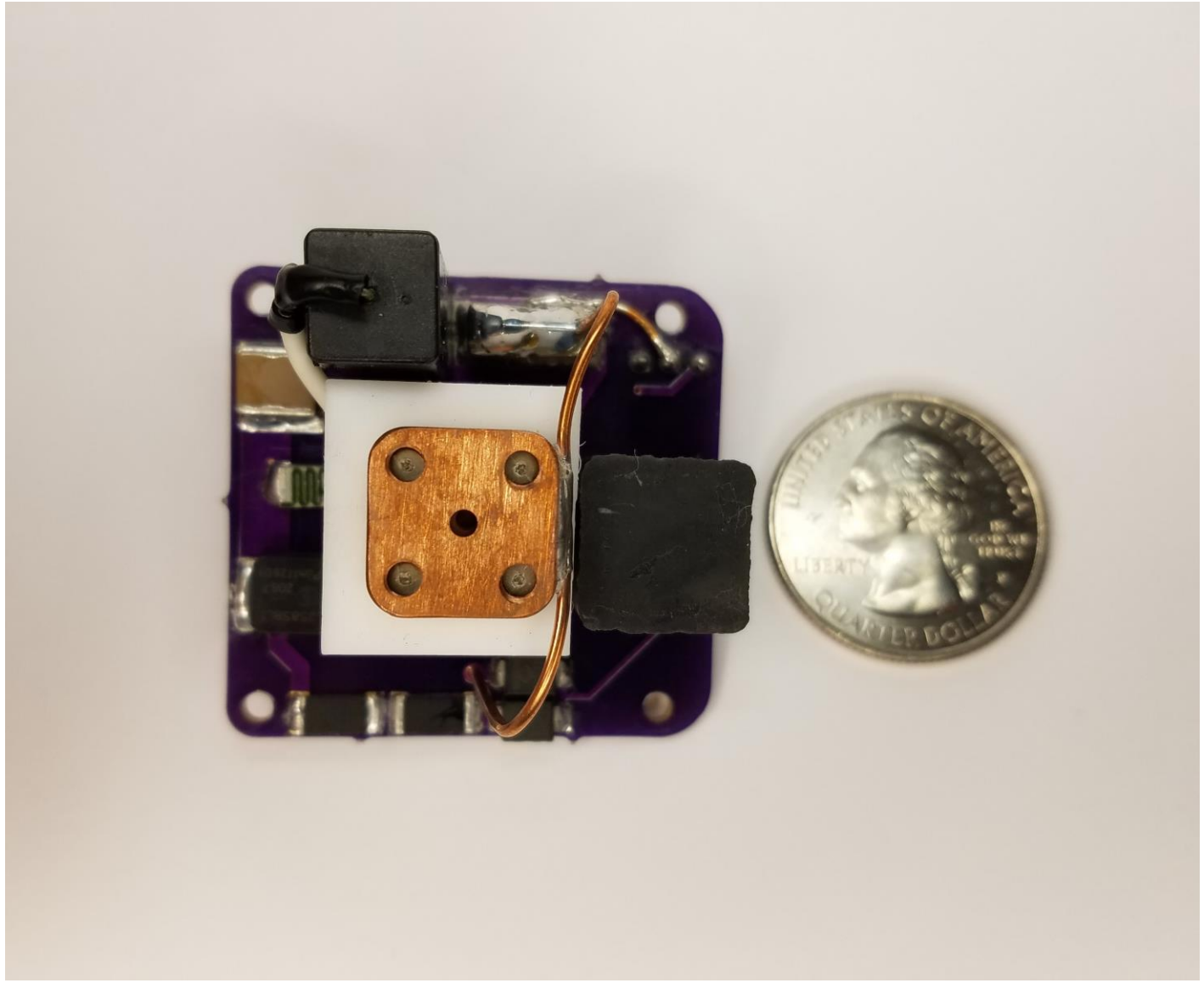
AIS-gPPT3-1C Integrated Propulsion Module



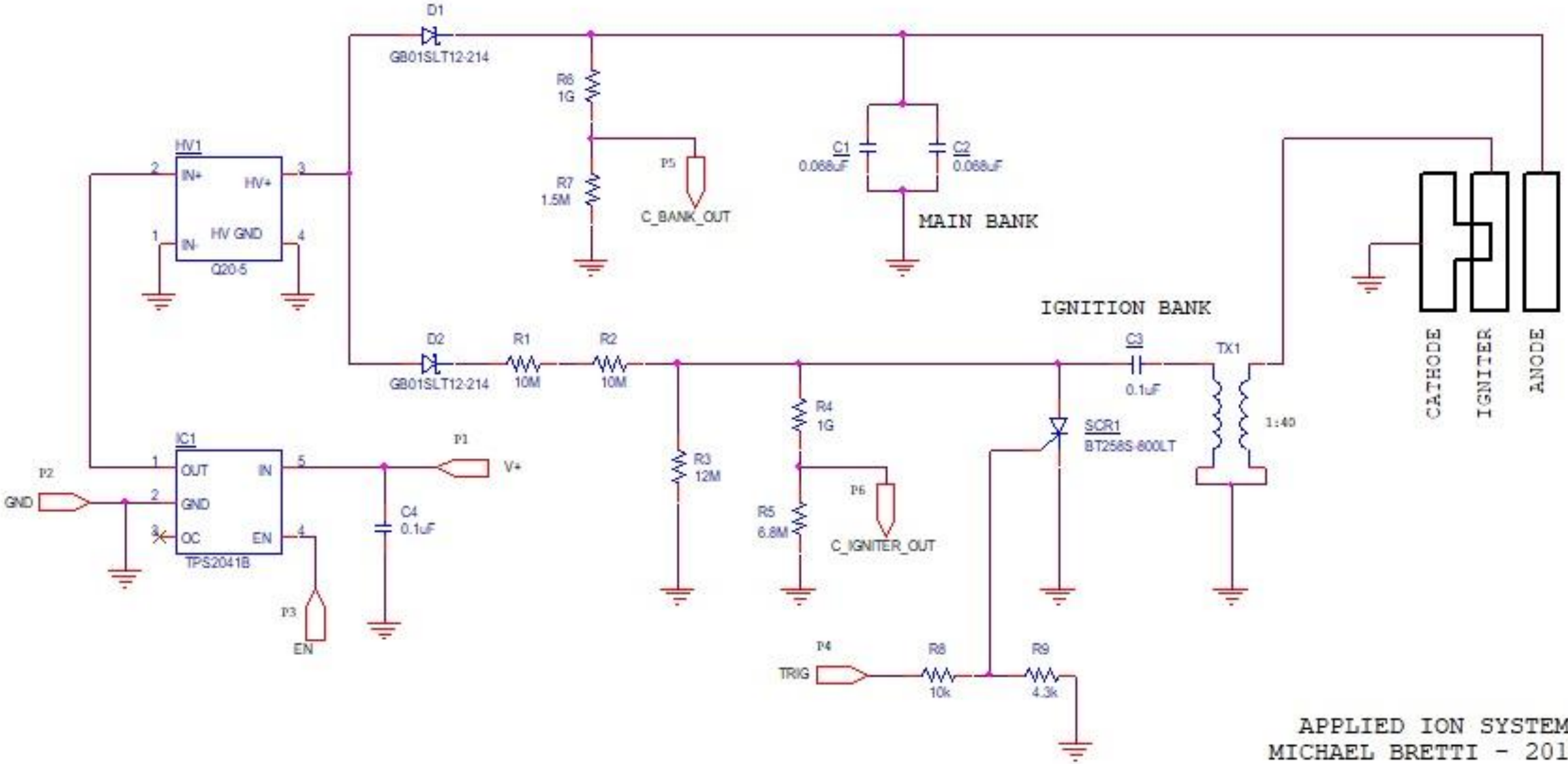


AIS-gPPT3-1C Integrated Propulsion Module - Design Overview

- 40mm x 38mm x 24mm
- 3.3V nominal operating voltage
- Power @3.3V: <550mW
- Impulse Bit @3.3V: 0.65uNs
- Rep Rate @3.3V: 0.25-0.33Hz
- Mass: 34 grams
- Current Tested Shot #: 2098
- Plug/Play: V+, GND, EN, TRIG
- Primary and ignition bank voltage readout

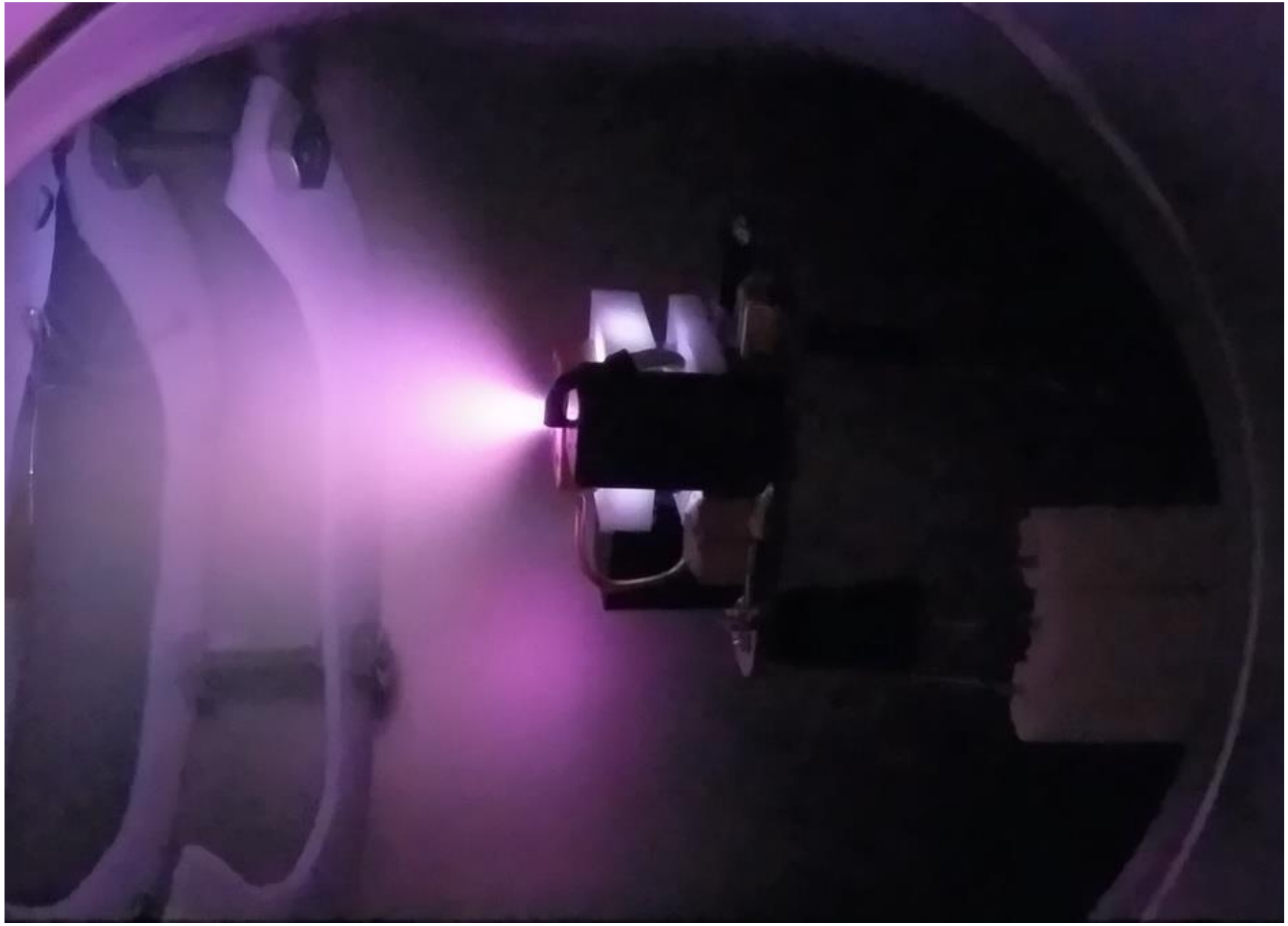


AIS-GPPT3-1C INTEGRATED PROPULSION MODULE V3 ELECTRONICS



APPLIED ION SYSTEMS
MICHAEL BRETTI - 2019

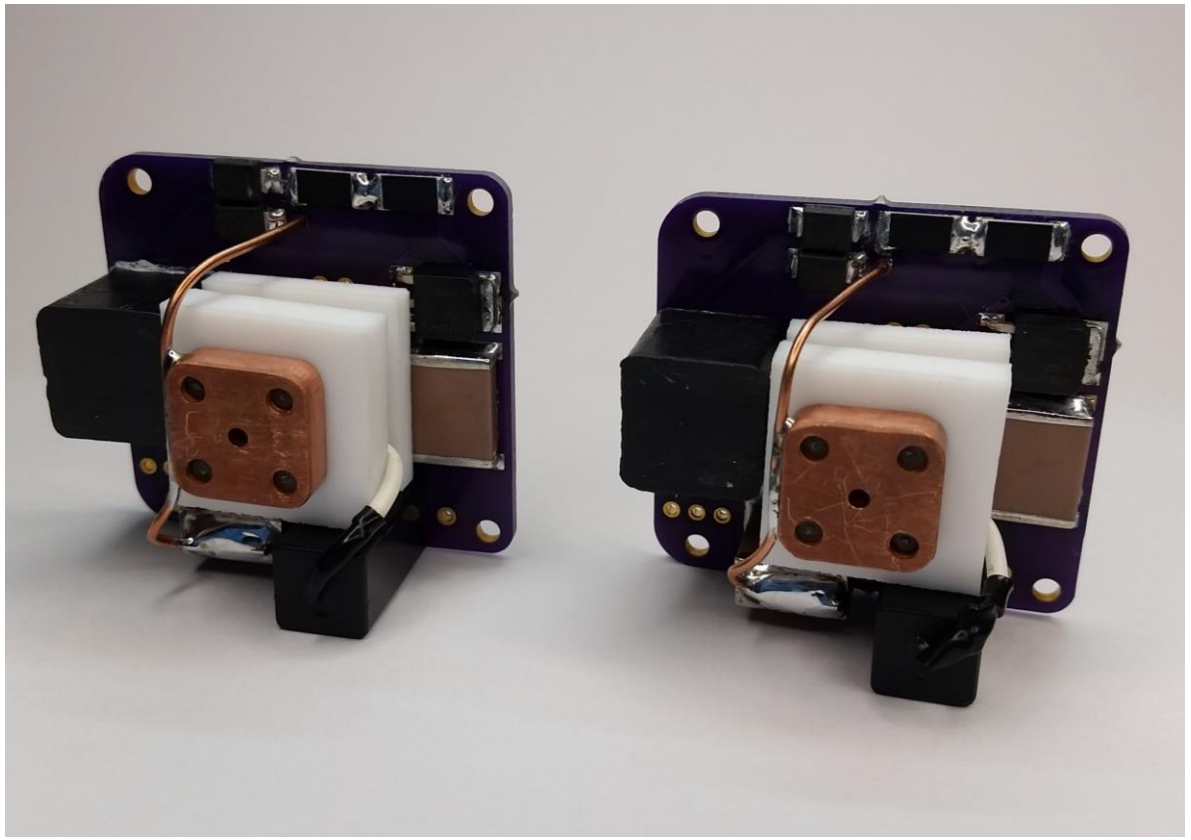
AIS-gPPT3-1C Propulsion Module – High Vacuum Testing

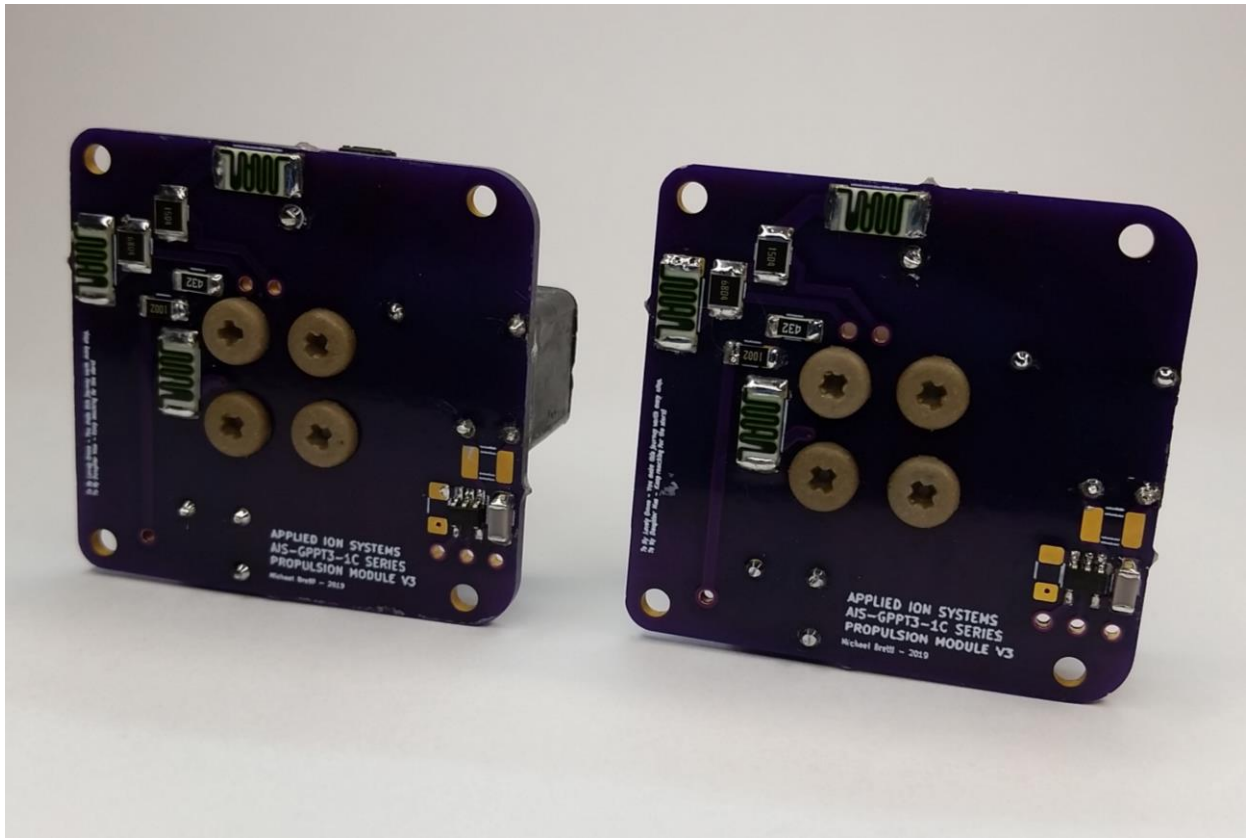


FUTURE WORK

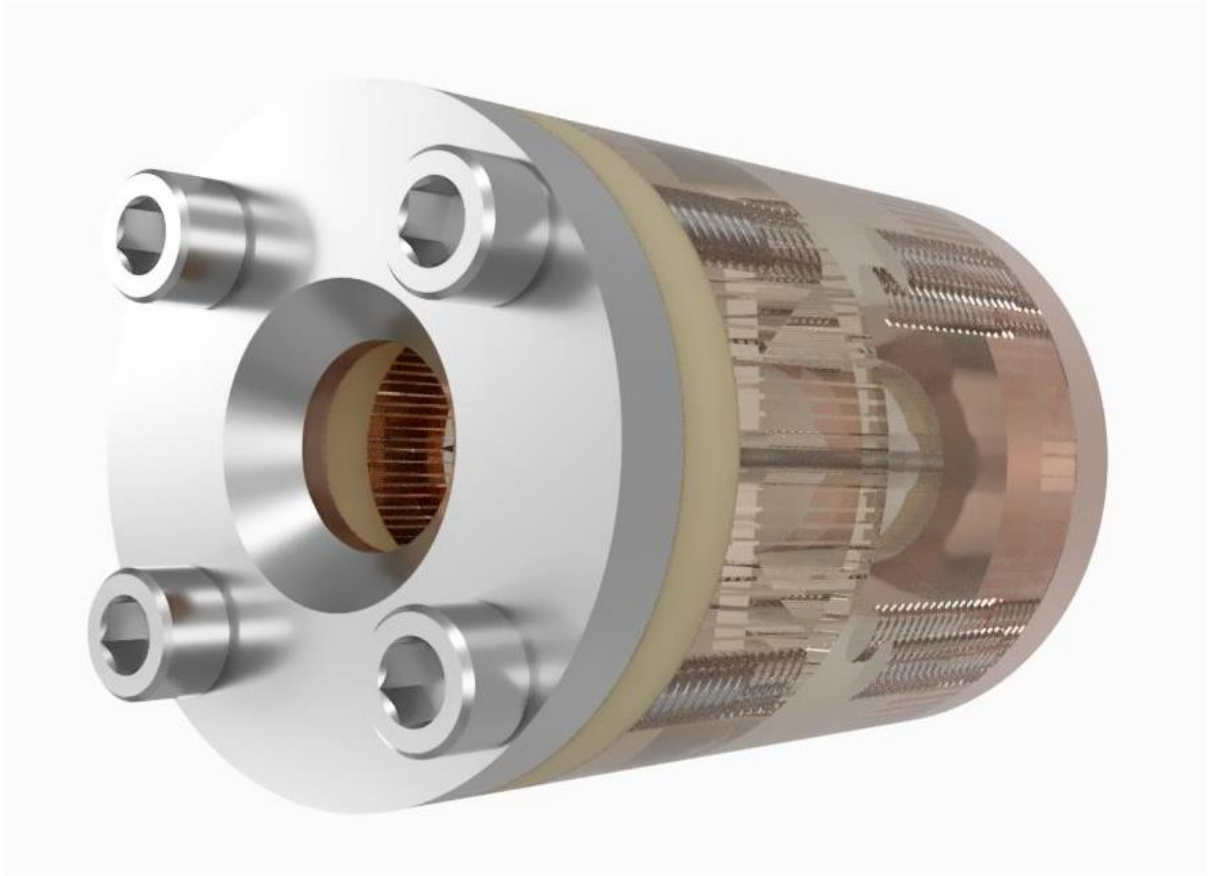
- Two completed AIS-gPPT3-1C (Version 3) propulsion modules off to Spain for joint collaboration project with Fossa Systems
  - Fully open source advanced mission with both satellite and thruster
  - Possible first ever PQ to fire propulsion in orbit
  - First fully open source, independent, home-built and engineered thruster to fire in orbit
- Continue optimization and characterization of current gPPT series thrusters
- V4 module – increased rep rate, lifetime testing to 100k shots, new fuels
- Make thrusters available – hobbyist, start-up, academic labs, etc.
- Other propulsion technology – colloidal electrospray, FEEP, RF Plasma, etc.

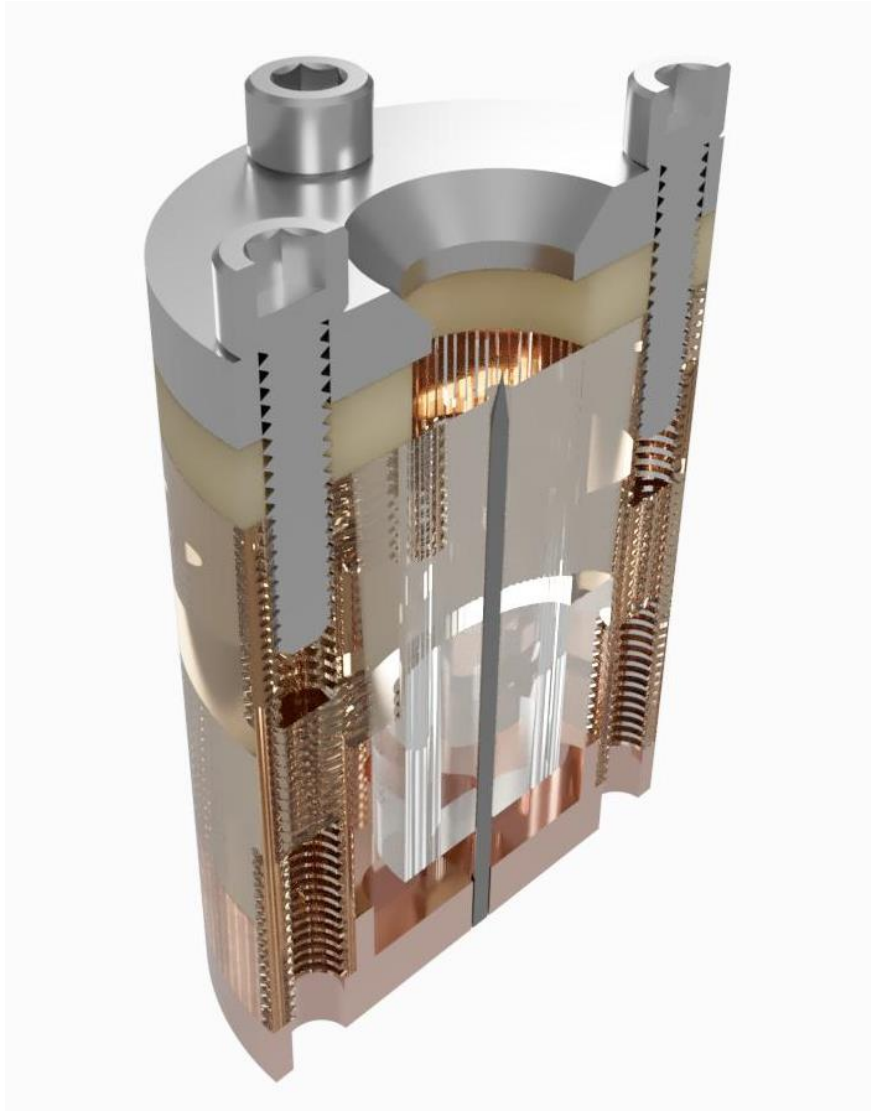
Fossa Systems-Applied Ion Systems Collaboration





Liquid Metal FEEP Concept Design





Thank You for Listening!