Modular Pulsed Plasma Electric Propulsion System for Cubesats

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Micro Cathode Arc Thruster

The Micro Cathode Arc Thruster (μCAT) is a novel concept of electric propulsion for small satellites. A collaboration between The George Washington University and NASA Ames Research Center has developed a modular propulsion system that consists of a single Printed Circuit Board (PCB) which controls an array of 4 thrusters for station keeping and attitude control maneuvers.

- The entire propulsion system's volume is less than 0.3U. All electronics and power distribution components are included in the board, as well as four thrusters
- Quasi-perfect ionization degree of 99% of the plasma particles in the exhaust plume, giving a near zero back flux
- Optimal thruster placement for attitude control maneuvers
- Potential station keeping applications (Fig.II)
- Designed to be compatible with the PhoneSat/ EDSN bus in a 1.5U cubesat form factor
- Thrust to mass ratio of 0.63μN/gr

Thrust	Isp	Power	Mass	Propellant
50 μN	2000-3000 s	5 W	300 g	Titanium

Table I: Main characteristics of a single Micro Cathode Arc Thruster at 50Hz

Previous work

- Performance and control of three discrete μCAT at the same time with a smartphone application
- Design of a functional PhoneSat-μCAT interface
- Long run Vacuum tests at Ames Research Center Engineering Evaluation Laboratory
- Parallel multi-thruster channel operation
- CAD Model and power electronics design
- Micro-controller software development

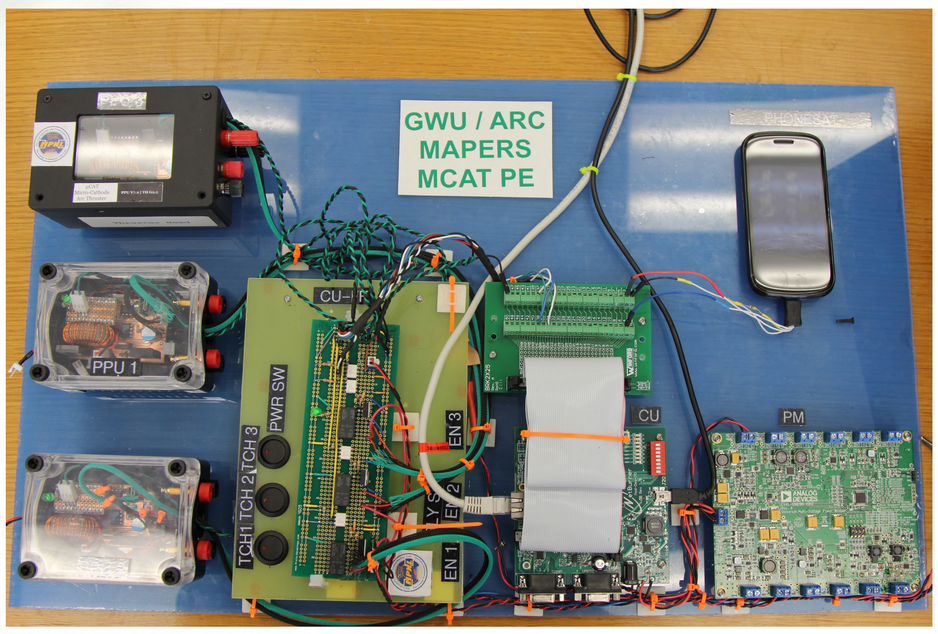

Figure I: Legacy bench top configuration of the electric propulsion system with the PhoneSat interface and three thruster channels

Design & Applications

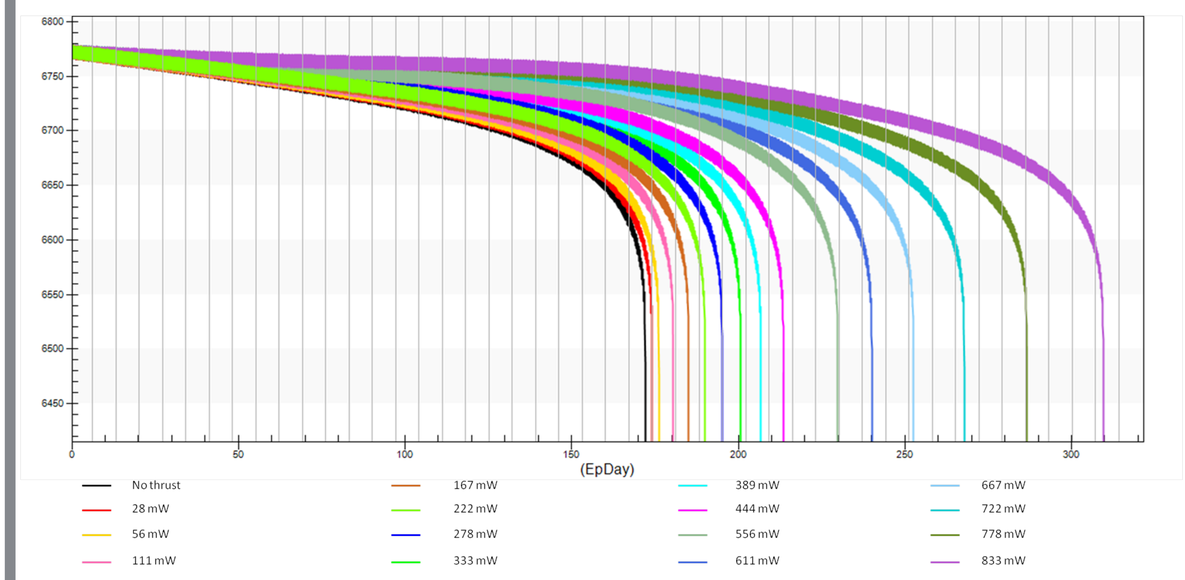

Figure II: Increased orbital lifetime. Semi-major axis evolution for various power values for a 1U Cubesat in a 400 km circular orbit

The design consists of an aluminum shell that encloses the following components (Fig.III):

- **Brass Screw** - serves as the anode
- **Cylindrical titanium hollow rod** - acts as the cathode and is the solid propellant of the system
- **Ceramic insulator** - separates the electrodes
- **Spring** - forces the propellant to the edge of the thruster head, in order to consume it uniformly as the thruster is firing
- **Spade lug terminals** - assure connectivity to cathode and anode

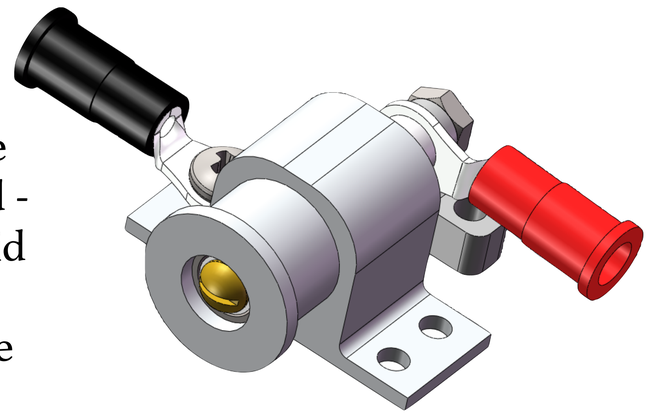

Figure III: Mechanical design of the μCAT

Performance

The μCAT consists of a very small thruster head (5mm of cross section), electrically powered by a Power Processing Unit (PPU) that manages the stored energy in an inductor. Vacuum arc discharges ablate the cathode material, forming cathode spots that transfer surface micro-plasma. The μCAT offers a reliable performance according to cubesat standards and supports the following features:

- Operation at multiple frequency and power ranges
- Power required for operation: 0.1 W/Hz per thruster
- Redundant control logics to ensure safety

Current Work

- Fabrication of a Printed Circuit Board that contains the Pulsed Plasma Unit circuitry and controls the electronics
- New mechanical design that ensures more reliability in the electrical connections
- Performance tests and thrust stand measurements at specialized facilities
- Application of an external magnetic field to improve performance
- Increase of Technology Readiness Level from 5 to 6

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