T0215 Spaceflight Testing of FEMTA Micropropulsion System for Interplanetary SmallSats

Technology Need

SmallSat utility is directly related to micropropulsion system mass, power, and impulse. Cold gas, electrospray, ion, and pulsed plasma systems can have masses up to 500 g and can require as much as 60 W of power depending on application. Magnetorquers are effective at maintaining an attitude but cannot be used beyond LEO. FEMTA is a novel non-toxic micropropulsion alternative for precision attitude control on interplanetary missions that has a system mass and thrust-to-power ratio significantly below industry alternatives.

Technology Concept

Film-Evaporating MEMS Tunable Array (FEMTA) exploits microscale effects of surface tension to produce highly tunable thrust at 200 !" and 90 s #$% at an input power <1 W using ultra-pure deionized water as propellant. FEMTA is microfabricated on a 1 cm x 1 cm x 0.05 cm silicon wafer and to date over 300 have been produced with a current yield rate near 100%. Four FEMTA thrusters were recently integrated into a 1U CubeSat providing >360 deg single-axis rotation in <1 min at <0.25 W input power. A zero-g propellant management system has been developed for FEMTA that uses the vapor pressure of an alcohol mixture to motivate a diaphragm within the propellant tank. A prototype zero-g tank has successfully demonstrated the core functionality of the concept in operating conditions.

TRLs: FEMTA Thruster: 5; Zero-g FEMTA Module: 4

Technology Development Team

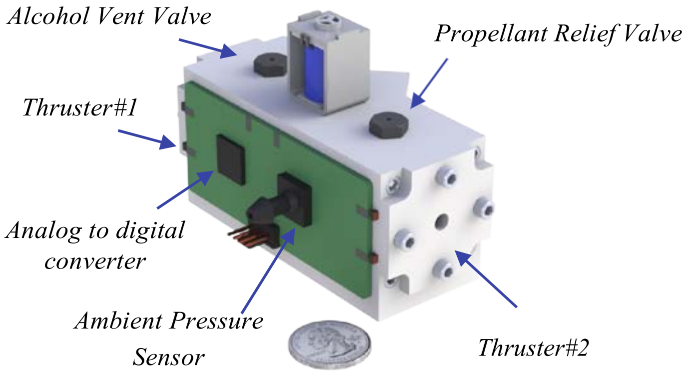
Purdue University: PI Alina Alexeenko – overall project/course coordination; **Co-PI** Steven Collicott – suborbital flight testing advisor; Dr. Anthony Cofer – FEMTA and lab testing advisor; **Graduate Students:** Katherine Fowee – FEMTA and undergraduate team coordination, Steven Pugia – avionics advisor; **Undergraduate Students** – design, build, fly course

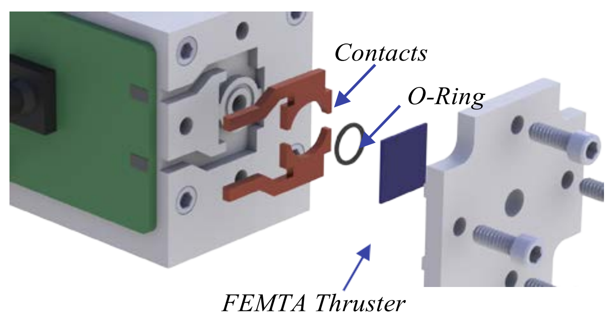
Test Apparatus

The test apparatus will be housed in a Blue Origin Single Payload Locker that is mounted externally to the launch vehicle. The experiment will consist of a single FEMTA propulsion module and diagnostics. The propulsion module will contain a zero-g propellant tank, at least two FEMTA thrusters, and control electronics. Solenoid valves will vent the zero-g tank and control the flow of propellant into the collection chamber. All valves and sensors will be operated by a microcontroller which will receive power from a 12 V LiFePO4 Battery. The diagnostics will include a camera, thermal sensors and propellant collection coupon. **Hazards**: Apparatus contains <1 g of an alcohol mixture.

Weight & Size: <25 lb; 20.31" x 16.45" x 9.02"

FEMTA Propulsion Flight Test Module





Flight Requirements/Objectives

Flight: New Shepard Launch Vehicle; Single Mission

Flight Readiness Date: December 1st, 2019

Special Requirements: (i) Payload shall be exposed to the ambient space environment; (ii) Payload must maintain a specific orientation during ascent.

Flight Test Plan: During ascent and while the ambient pressure is less than 10 kPa, the zero-g tank will vent to equalize with the environment. Once in zero-g, a valve will open to allow propellant to flow from the propellant tanks to a collection chamber. The FEMTAs will also be powered during this time to simulated operation. Alcohol vapor pressure and temperature, propellant flow rates, ambient pressure, propulsion module acceleration, and video will be recorded at all times throughout the experiment. FEMTA thrusters will be inspected and tested before and after the flight.

Technical Objectives: (i) Develop a spaceflight rated FEMTA propulsion module; (ii) Prove the operability of the FEMTA propulsion module in spaceflight operating conditions (iii) Verify the integrity of the FEMTA thruster under spaceflight loading conditions.

Technology Advancement

Insights from a successful test campaign will enable the technology to advance to fully integrated CubeSat flight testing.

Anticipated Post-Flight TRL: 6

Technology End Users

Applications: (i) Precise attitude control for SmallSats to PicoSats on missions in low Earth orbit and beyond; (ii) Attitude control of large-scale deployable structures in space such as antennas, solar sails and sunshields.

Users: Commercial and government entities flying SmallSat to PicoSat sized payloads beyond LEO.

Technology Area TA 2.1.7 (In-Space Propulsion Technologies – Micropropulsion)

08/2018