National Aeronautics and Space Administration

NASA facts

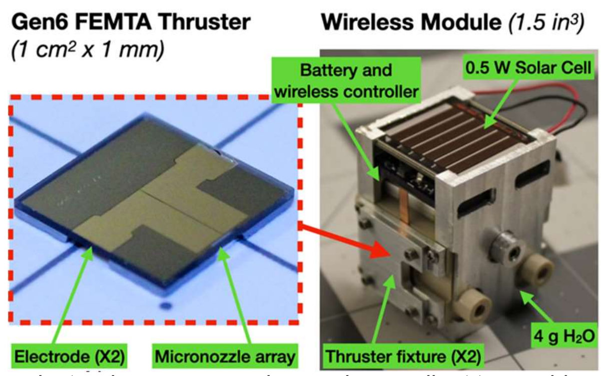
Distributed Attitude Control and Maneuvering for Deep Space SmallSats

Low-power SmallSat Attitude Control

The aim of the Distributed Attitude Control and Maneuvering for Deep Space SmallSats project is to advance a multi-purpose, deep space mission-enabling technology for low-power attitude control of small satellites to a flight demonstration technology readiness level (TRL). The Film-evaporation micro-electro-mechanical (MEMS) tunable array (FEMTA) small satellite technology combines innovative systems such as MEMS microfabrication and microscale effects in fluid surface tension to produce a thermally actuated capillary valve. Using water as the propellant, the FEMTA thruster can generate finely controllable thrust at a thrust to power ratio of approximately 300 microNewton per Watt (W).

The compact (<1.5 in^3), low-power (<1 W) micropropulsion technology enables high-precision positioning and attitude control for spacecraft ranging from nanosats (<10 kg) down to femtosats (<100 g). This feature would allow these small satellites to qualify for missions outside Earth's magnetosphere where precision pointing is necessary and magnetorquers are ineffective. These distributed micropropulsion modules could also provide attitude control for largescale deployable structures such as flexible antennas, solar sails, and tethered spacecraft. The technology enables extremely small impulse bits at <200 μN·s, well suited for formation flying at low-Earth orbit, medium-Earth orbit, lunar and interplanetary small satellites. Pure water vapor propellant is clean and available by in situ resource utilization (ISRU).

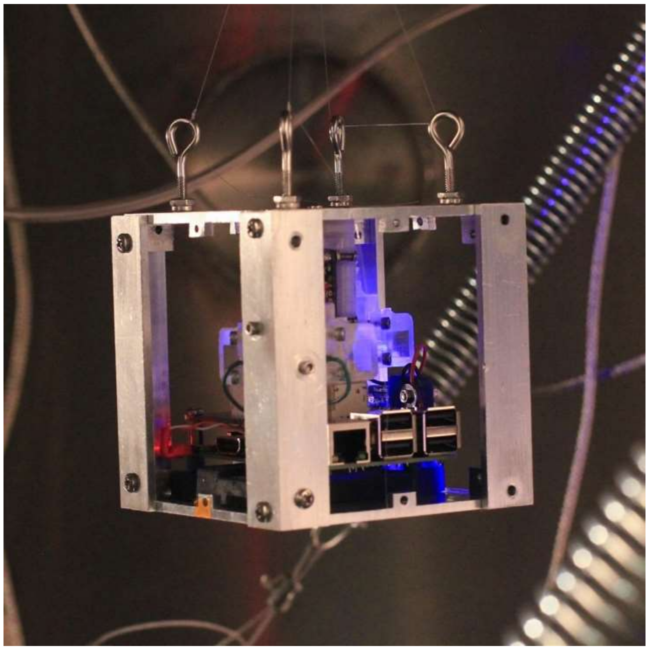
The FEMTA technology exploits microscale effects of surface tension and hydrophobicity to produce highly tunable thrust at 300 μN/W and 90 s specific impulse (Isp) with pure water as a propellant. Over 500 thrusters have been microfabricated since 2013, spanning six design generations. Many microfabrication issues have been identified by electrical and vacuum thrust testing, and are addressed through material selection and improvement of the microfabrication techniques. Sixth



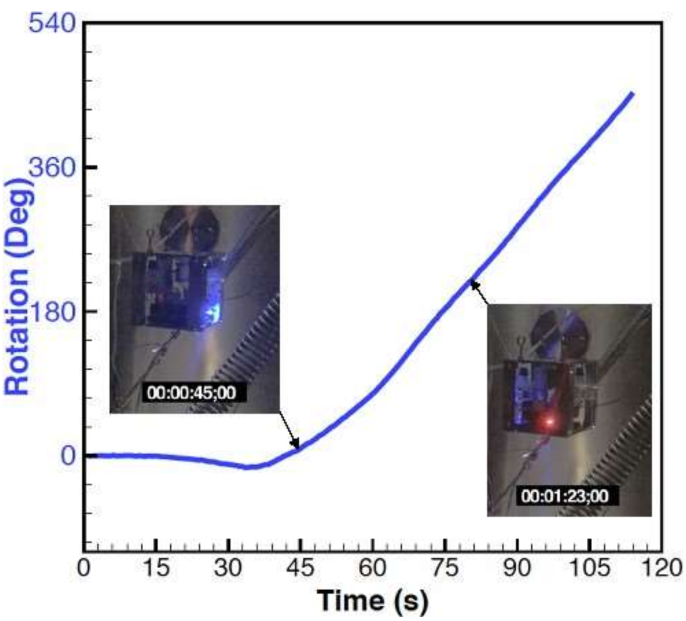
electronics, power, and enough propellant to provide 4 N·s impulse.

generation FEMTA thrusters are designed for multi-year spaceflight operation and are optimized for reliability and robustness. FEMTA is at TRL5 with recent demonstration of four fourth generation thrusters integrated in a 1-unit (1U) CubeSat providing >360 degrees 1-axis rotation in <1 min at <0.25 W input power. In 2022, a sixth generation FEMTA thruster and FEMTA zero-gravity propellant feed system will be tested on a suborbital trajectory under simultaneous vacuum and micro-gravity environments.

Purdue University, School of Aeronautics and Astronautics and Birck Nanotechnology Center are collaborating with NASA Goddard Space Flight Center and NASA Marshall Space Flight Center on this project. The Distributed Attitude Control and Maneuvering for Deep Space SmallSats project is managed and funded by the Small Spacecraft Technology Program (SSTP) within the Space Technology Mission Directorate. The SSTP expands U.S. capability to execute unique missions through rapid development and in space demonstration of capabilities for small spacecraft applicable to exploration, science, and the commercial space sector. The SSTP will enable new mission architectures through the use of small spacecraft with goals to expand their reach to new destinations, and challenging new environments.



1U CubeSat model with duplex Gen4 FEMTA thrust cells in the high vacuum chamber during testing.



1U CubeSat rotation due to single Gen4 FEMTA thruster firing at 0.18 W input power at high-vacuum environment. The rotation angle is measured by the on-board magnetometer.

For more information about the SSTP, visit:
www.nasa.gov/directorates/spacetech/small_spacecraft

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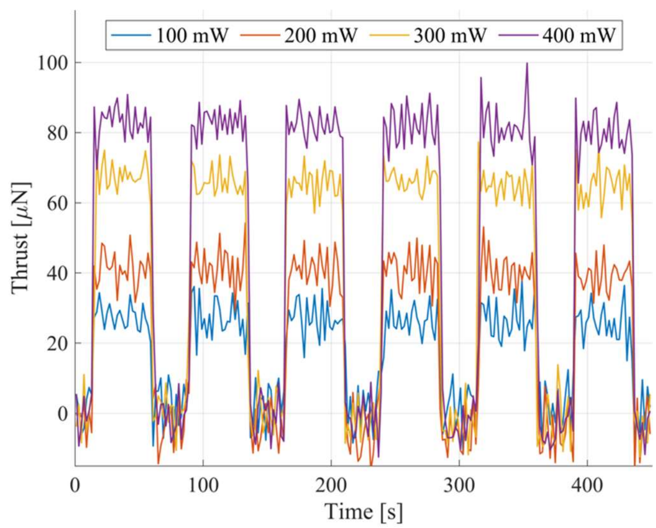

Thrust stand data for Gen6 FEMTA thruster. Multiple power levels are applied in 60 s pulses separated by 30 s delay.

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