National Aeronautics and Space Administration

NASAfacts

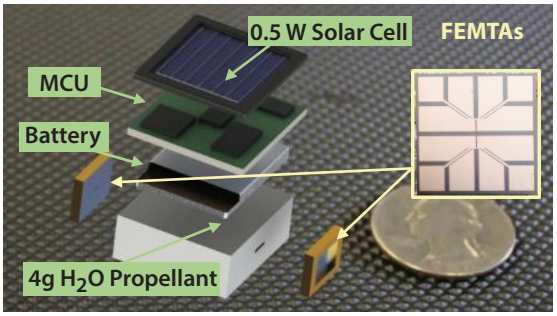
Distributed Attitude Control and Maneuvering for Deep Space SmallSats

Low-power SmallSat Attitude and Thermal 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 and thermal control of small satellites to a flight demonstration technology readiness level (TRL). The film-evaporation microelectromechanical systems tunable array (FEMTA) small satellite technology combines innovative microelectromechanical systems (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 about 200 microNewton per Watt (W).

The compact (<1 in^3), low-power (<1 W) micropropulsion and thermal management technology enables high-precision positioning and attitude control for spacecraft from the nanosat (<10 kg) down to the femtosat (<100 g) range. 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 large-scale deployable structures such as flexible antennas, solar sails and tethered spacecraft. The technology enables extremely small impulse bits at 10s mN·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 200 μN/W and 90 s specific impulse (Isp) with pure water as a propellant. Over 300 thrusters have been microfabricated since 2013 with many fabrication issues identified by electrical and vacuum thrust testing and addressed through

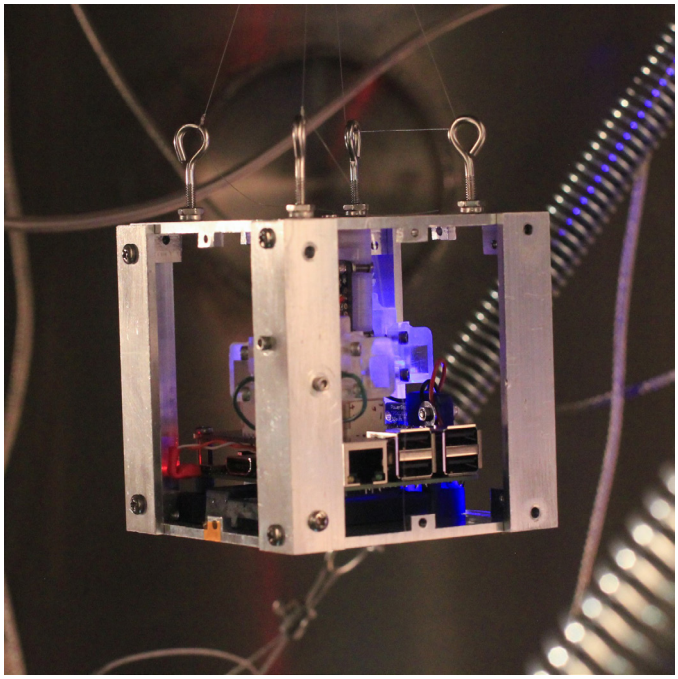


Conceptual schematic of a wireless FEMTA module with electronics, power and propellant to provide 4 N·s impulse

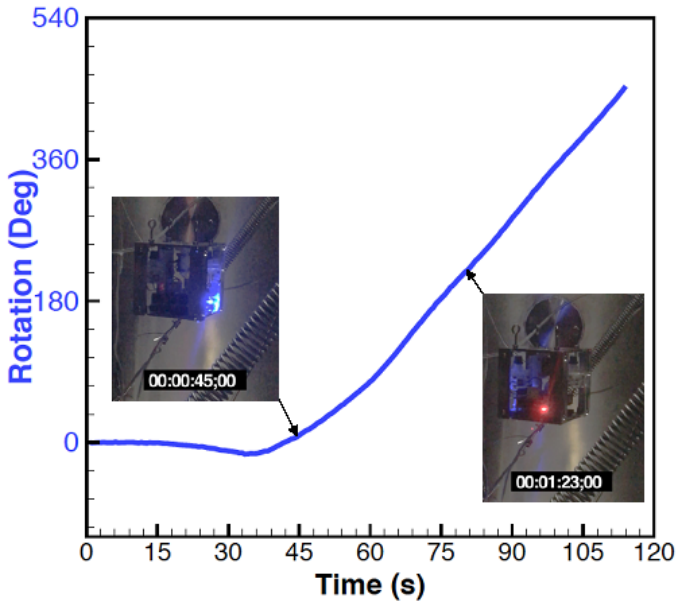
materials and <5% to close to 100%. FEMTA is at TRL5 with recent demonstration of 4 thrusters integrated in a 1-unit (1U) CubeSat providing >360 degrees 1-axis rotation in <1 min at <0.25 W input power. The goal of this project is to achieve flight readiness advancement to TRL 6.

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.



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



1U CubeSat rotation due to FEMTA thruster D 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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