

## FY23 Topic Areas Research and Technology Development (TRTD)

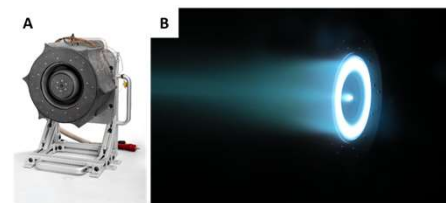
### Advancing Electric Propulsion Technology with 3D Printing (AdEPT3D)

**Principal Investigator:** Samad Firdosy (357); **Co-Investigators:** Richard Hofer (353), Scott Roberts (357), Takuro Daimaru (353), Jacob Simmonds (353), Eric Smith (353), Robert Dillon (356)

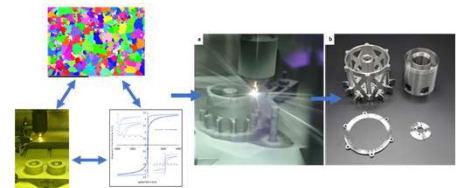
**Strategic Focus Area:** Additive Manufacturing, Multifunctional Systems

**Objective:** The objective of this work is to demonstrate integrated thermal management technologies to enable the H10 Hall thruster to operate at more than twice the power density of state-of-the-art (SOA) flight thrusters.

**Background** JPL is developing a low-cost, low-mass, 10-kW (H10) Hall thruster that features deep power throttling (50:1), high specific impulse ( $I_{sp} = 3000$  s), and long-life magnetic shielding technology [1-2]. A key feature of the H10 thruster is operation at high power densities (2x SOA) which severely stress current thruster thermal management methodologies. Processes for additively manufacturing Hipercor®, the alloy used for magnetically shielded Hall thrusters, have recently been developed by this team [3,4]. Simultaneously, methods to integrate channels that can accommodate single or 2-phase thermal systems into structures via additive manufacturing have also been developed [5]. By combining these technologies, the low effective thermal conductivity of Hipercor® structures could be increased by at least a factor of 20, from 30 W/m-K to over 600 W/m-K.

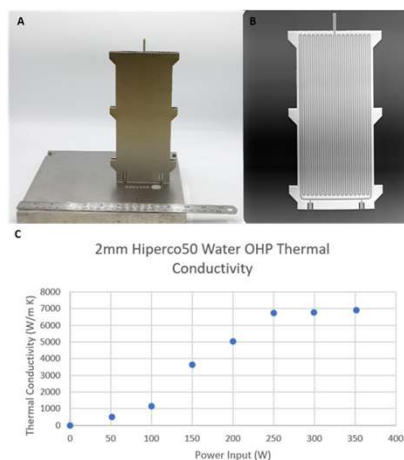


Photographs of (A) H10 Thruster and (B) H10 thruster test



Previous additive manufacturing development of Hipercor®, MaSMi Hall thruster components

A) Oscillating heat pipe bench test article 3D printed in Hipercor50 alloy. B) Corresponding x-radiograph showing internal channel detail free of defects. C) Effective thermal conductivity measured as a function of heater power input.



**Approach and Results:** We developed detailed thermal and magnetic models for the H10 thruster and performed trade studies to inform design and integration of OHPs into a thruster core, showing dramatic decreases in the operating temperature of critical components without compromising magnetic shielding performance. We also designed, printed and bench tested Hipercor50 test plates with integrated oscillating heat pipes (OHPs) demonstrating effective thermal conductivities ~150 times higher than the base Hipercor50 material.

**Significance of Results/ Benefits to NASA/JPL:** This technology will enable ultra-compact, high-performance thrusters that expand the range of unique JPL propulsion capabilities that are needed to sustain JPL's competitive advantage in electric propulsion for our most ambitious missions.

#### PI/Task Mgr. Contact Information:

[Samad.a.Firdosy@jpl.nasa.gov](mailto:Samad.a.Firdosy@jpl.nasa.gov), 626-344-5131

National Aeronautics and Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California

[www.nasa.gov](http://www.nasa.gov)

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#### References:

- [1] Hofer, R. R., "Development and Characterization of High-Efficiency, High-Specific Impulse Xenon Hall Thrusters," Ph.D. Dissertation, Aerospace Engineering, University of Michigan, Ann Arbor, MI, 2004.
- [2] Mikelides, I. G., Katz, I., Hofer, R. R., and Goebel, D. M., "Magnetic Shielding of Walls from the Unmagnetized Ion Beam in a Hall Thruster," *Applied Physics Letters* 102, 2, 023509 (2013).
- [3] Firdosy, S., et al "Processing-Microstructure-Property Relationships in a Laser-Deposited Fe-Co-V Alloy" *Advanced Engineering Materials*, 2021
- [4] Firdosy, S., et al "Compositionally graded joints between magnetically dissimilar alloys achieved through directed energy deposition" *Scripta Materialia*, 2021
- [5] Odagiri, K., et al "Three-dimensional heat transfer analysis of flat-plate oscillating heat pipes" *Applied Thermal Engineering*, 2021