National Aeronautics and Space Administration

Development of Ultra-High Temperature Metal Matrix Composites Coatings

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Program: FY22 SURP
Strategic Focus Area: Chemical/Non-Chemical propulsion

Objectives: To use laser deposition (LD) to develop ultra-high-temperature coatings comprising metal-matrix-composites (MMCs) made from refractory metals and high-temperature carbides. The work will focus on combining Mo, W, Nb, with WC to produce dense, crack-free coatings so that high-temperature testing can be performed.

Connection to NASA & JPL Strategic Technologies

NASA Technology Taxonomy

01 Propulsion Systems
- 1.1 Chemical Space Propulsion
- 1.4 Advanced Propulsion

09 Entry, Decent and Landing
- 9.1 Atmospheric Entry

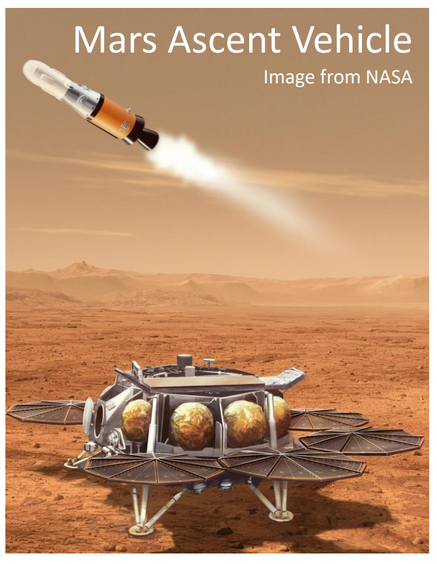
12 Manufacturing, Materials & Structures
- 12.1 Materials
- 12.4 Manufacturing

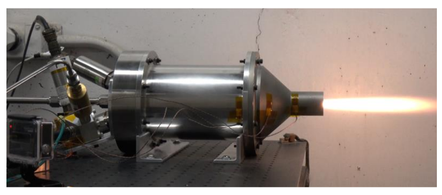
14 Thermal Management Systems
- 14.3 Thermal Protection Components

JPL Core Technology/Need

In-Situ Planetary Exploration
- Hot temperature operations
- Propulsion

Sample Return
- Ascent vehicles
- Systems for extreme environments
- Thermal protection systems
- Entry Systems

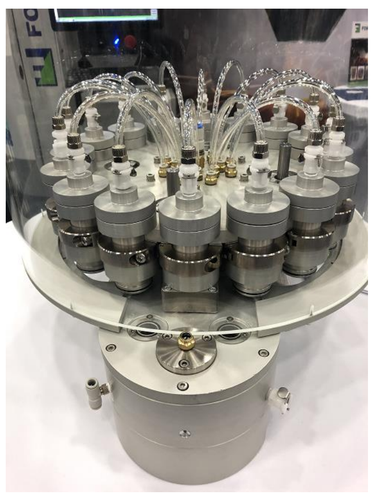




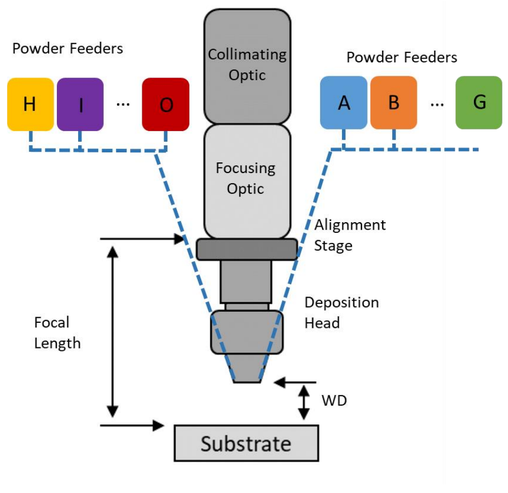
3D Printed Nozzle in Hybrid Propulsion System

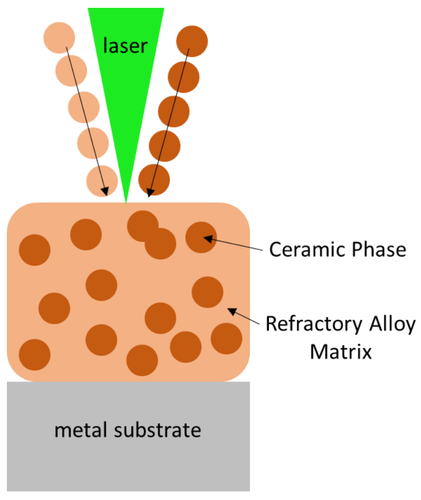
High Temperature Oxidation and Ablation

Background: JPL and Cornell both possess custom LD coating technology capable of melting and depositing high-temperature metals on substrates with complex geometries. Metal alloy development is needed to prevent cracking in these coatings before high-temperature testing can be performed to measure oxidation and ablation.

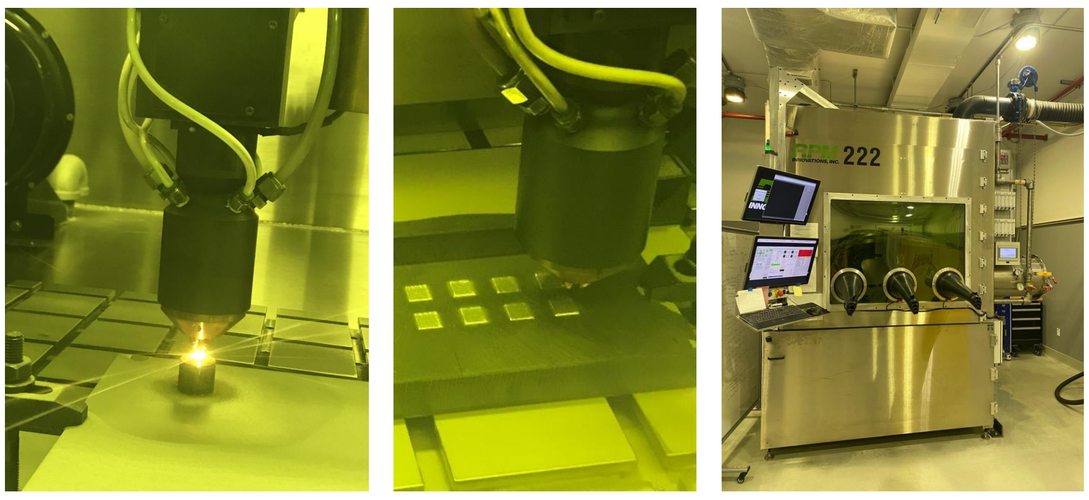


Multi-material LD 3D printer at Cornell University



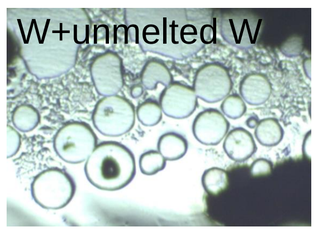


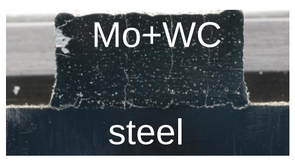
Schematic of refractory composites

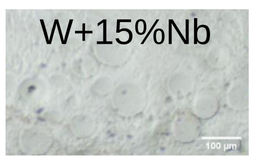


Multi-material cladding systems at NASA JPL

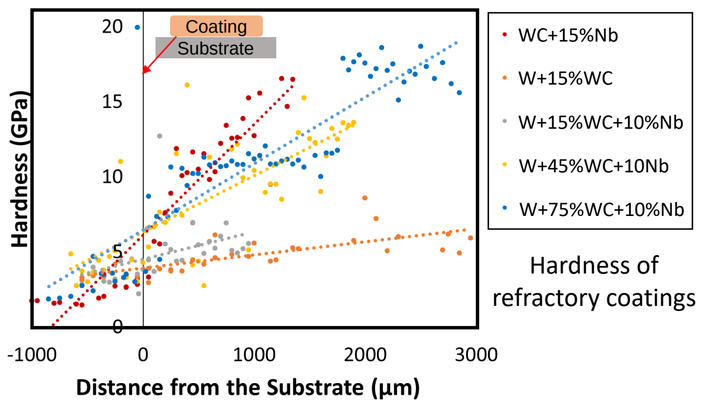
Approach and Results: In Year 1, we explored process parameters to create dense, crack-free coatings from pure W, W-Nb, WC-Nb, W+Mo, W+WC, Mo+WC, and pure Mo, using both JPL and Cornell's LD systems. Despite challenges, we successfully produced a variety of coatings with variable microstructure, hardness and toughness.



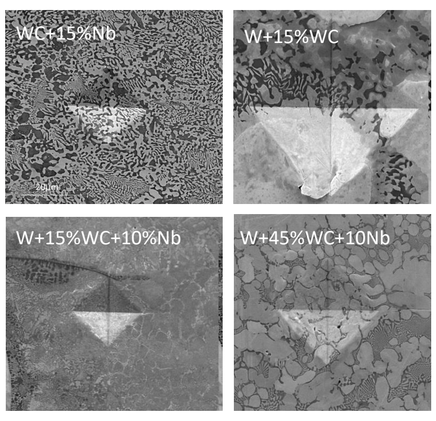




We explored different laser powers and different additives to reduce cracking and make dense coatings



Hardness of refractory coatings



Significance/Benefits to JPL and NASA: This work supports JPL core technology needs related to high-temperature materials for hybrid propulsion systems, thermal protection systems, and entry systems. This is applicable to JPL mission needs like the Mars Ascent Vehicle & sample return.

National Aeronautics and Space Administration

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www.nasa.gov

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Publications/Conference Talks:

"Additive Manufacturing of Refractory Metallic Materials," TMS Annual Meeting 2023, Atieh Moridi, Douglas Hofmann, Samad Firdosy, Ashlee Tianna Gabourel and Poulomi Mukherjee (2023)

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