FY23 Strategic University Research Partnership (SURP)

Development of Ultra-High Temperature Metal Matrix Composites Coatings

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Objectives: Refractory metals and carbides have excellent high-temperature properties, however, their high melting points and susceptibility to cracking during solidification make them challenging to process, especially through additive manufacturing (AM) technologies. We used Directed Energy Deposition (DED) to create a functionally graded refractory coating (W-WC-Nb system on a titanium substrate) by varying the composition through substrate dilution.

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

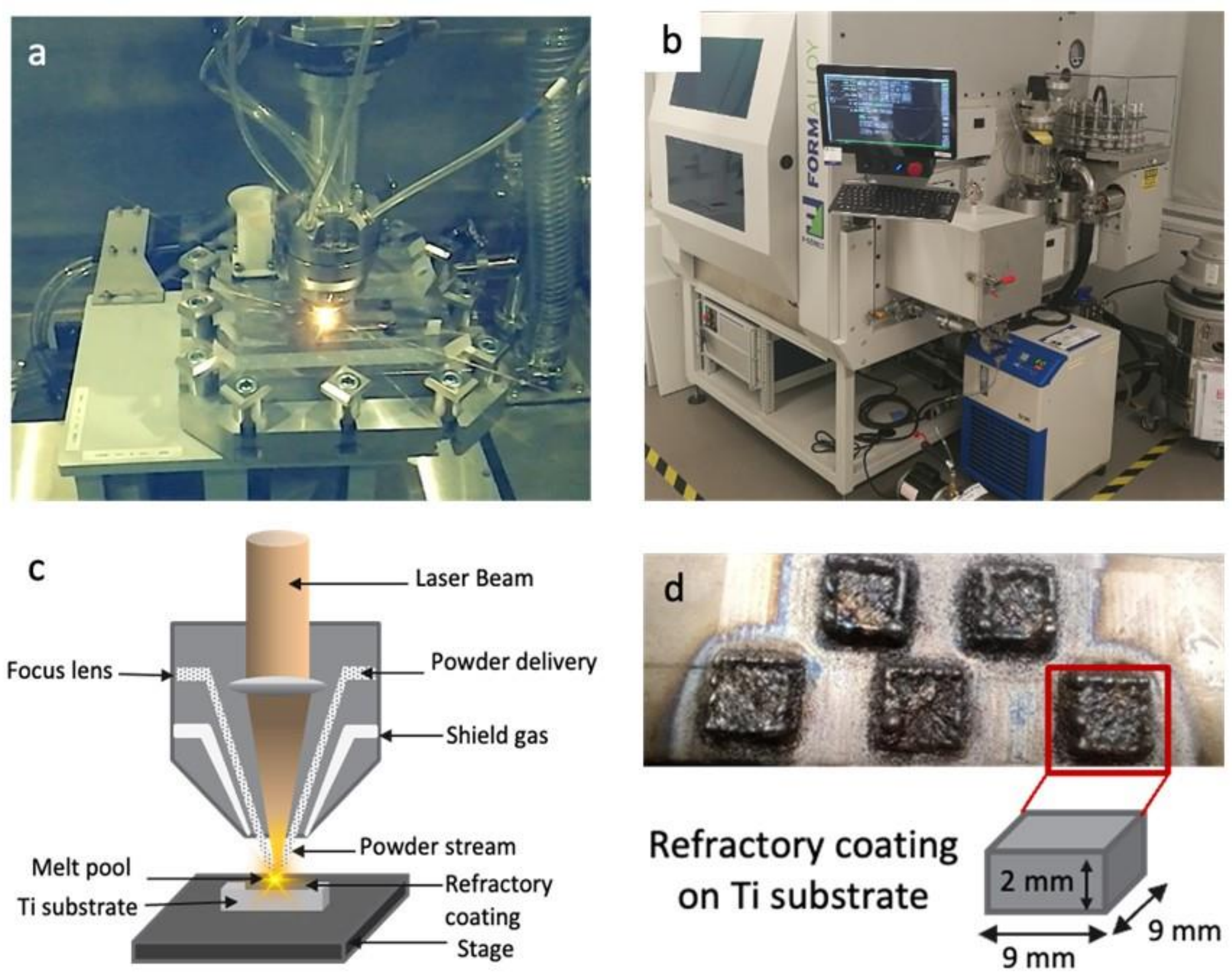
In-Situ Planetary Exploration
- Hot temperature operations
- Propulsion

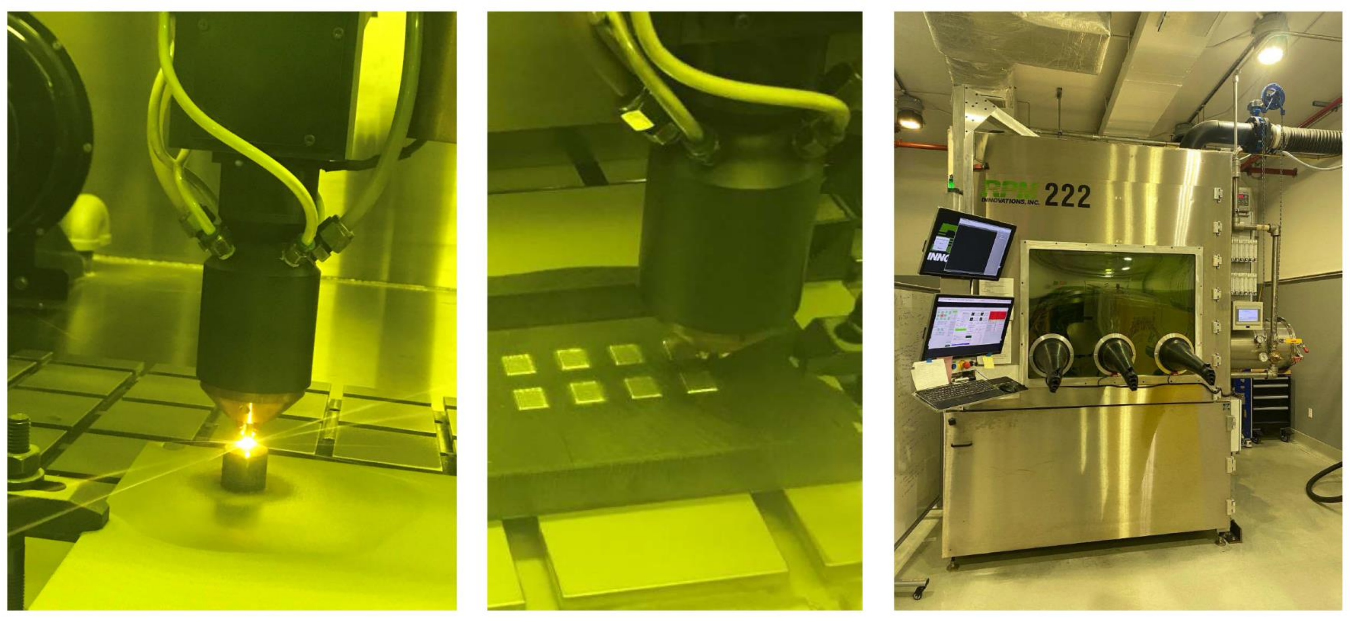
Sample Return
- Ascent vehicles
- Systems for extreme environments
- Thermal protection systems
- Entry Systems

3D Printed Nozzle in Hybrid Propulsion System

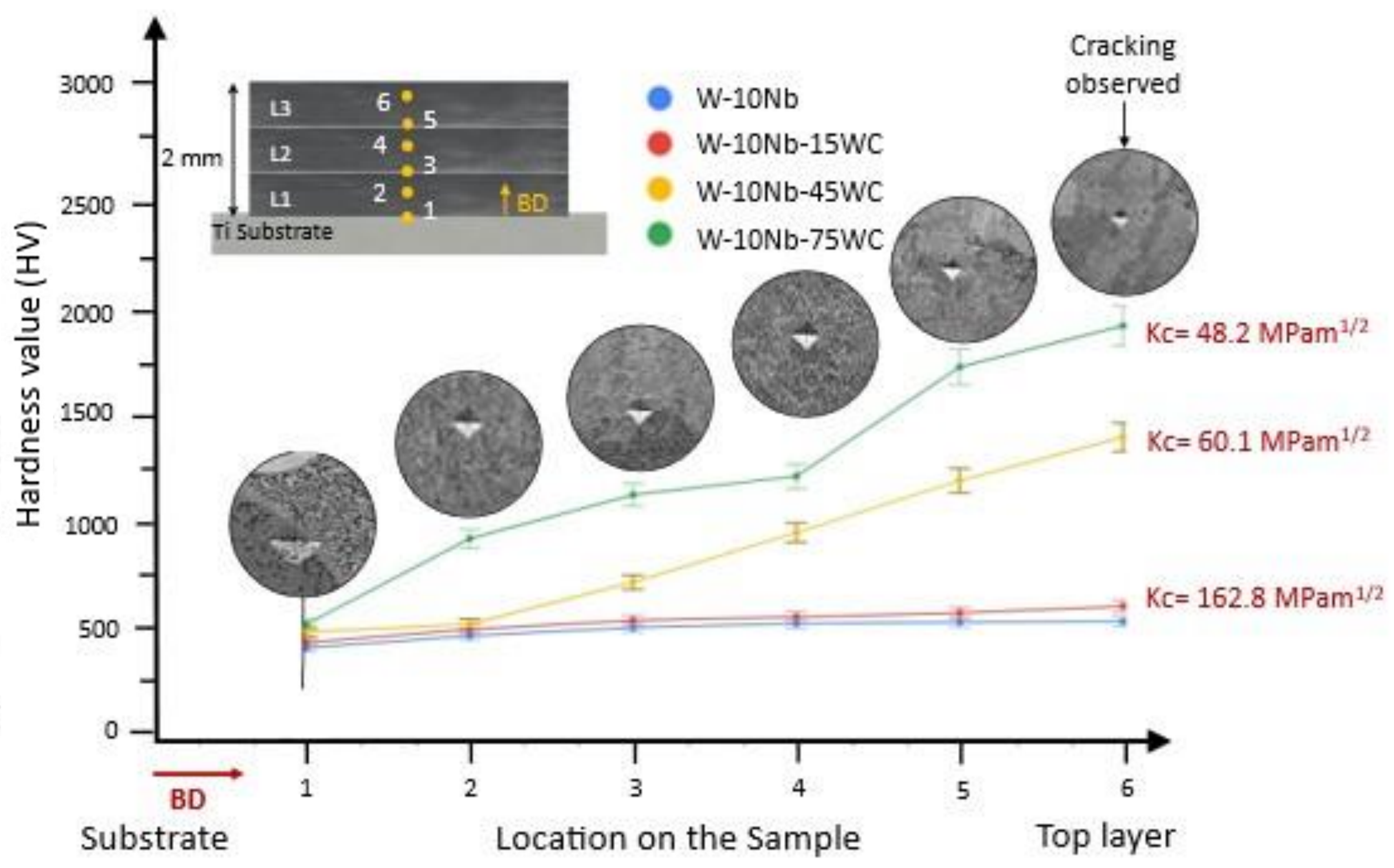
High Temperature Oxidation and Ablation

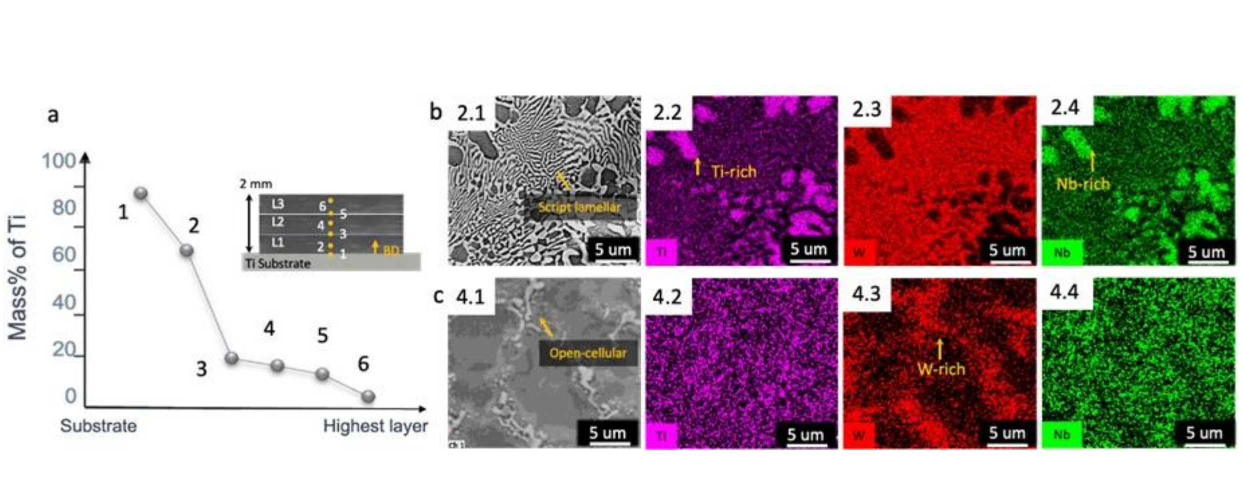
Background: JPL and Cornell each possess unique 3D printing technologies to explore high-temperature, refractory coatings. Cornell utilized their system to deposit W-Nb-WC coatings with different composition onto titanium substrates. The first two layers of the coating partially melt the substrate and create a gradient of composition that blends the titanium with the high-temperature coating, improving adhesion and thermal properties

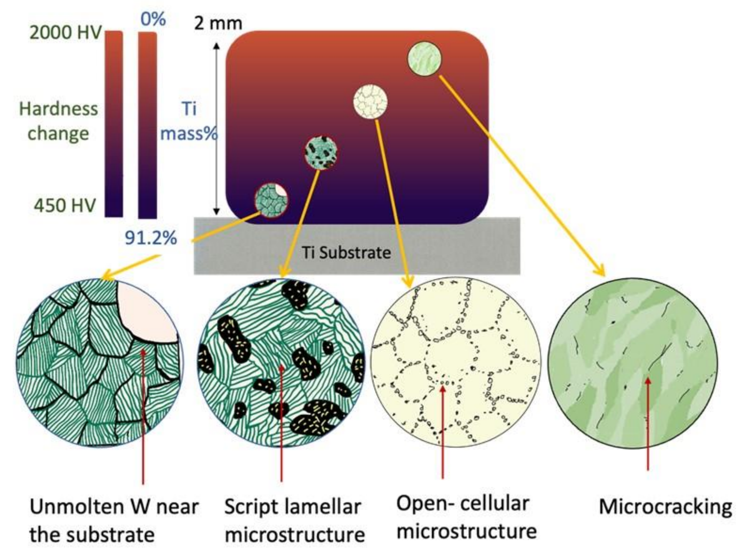




Significance to JPL and NASA: We have developed a method for producing dense, crack-free refractory metal composite coatings onto titanium parts, paving the way for a new class of high-temperature propulsion applications







Approach and Results: (left) A map of hardness vs. distance from substrate for W-Nb-WC coatings with different compositions showing tunable hardness and toughness. (above) Plot showing functionally graded composition of coating obtained from alloying the titanium substrate. (above right) Microstructures in the different coating regions

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Publications:

Poulomi Mukherjee, Ashlee Gabourel, Samad A Firdosy, Douglas C. Hofmann, Atieh Moridi, "Additive manufacturing of functionally gradient refractory coatings using substrate dilution and in-situ carbide formation," in preparation (2023)

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