BIG: Building Intelligent Gradients in additively manufactured space engine materials via a multiscale predictive framework

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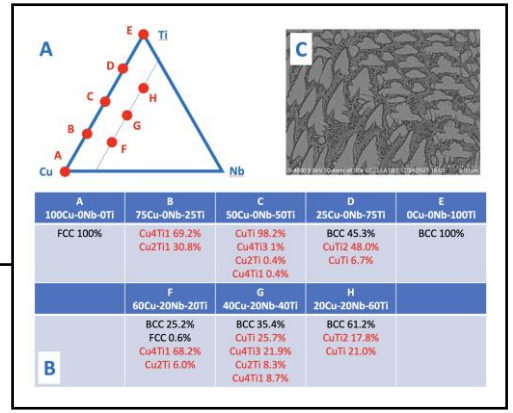
Research objective:

Goal: Establish advanced physics-based models to enable predictive simulations of process-structure-property relationships for scalable Cu-Nb-Ti AM-FGMs under relevant space engine component conditions

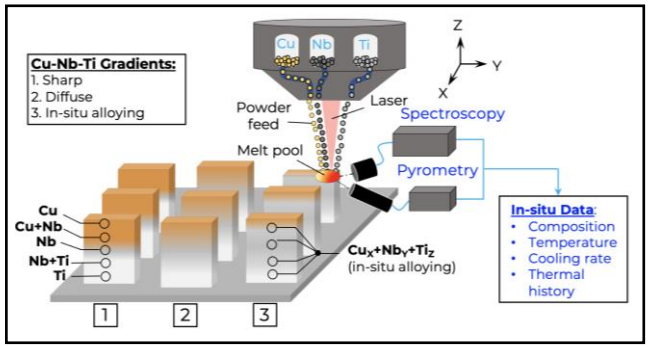
Approach:

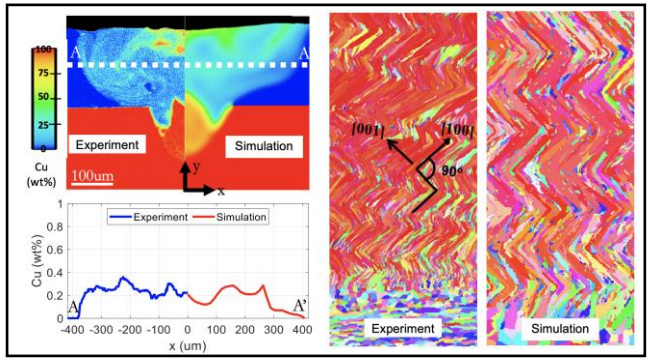
- Develop process models to control composition, defects, microstructure, and other process outcomes for blown powder AM-FGMs.
- Employ mesoscale CFD and cellular automata models to simulate thermo-solutal conditions and microstructure evolution during solidification.

Intelligent Cu-Nb-Ti gradients

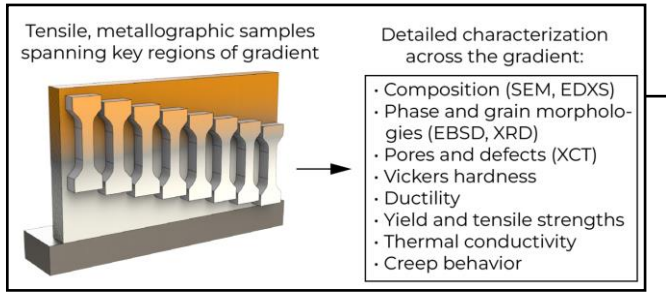


Scalable blown powder DED-AM





Predictive μstructure models



Multiscale FGM structure & properties

- A <u>new strategy of composition design in AM-FGMs</u> to manipulate microstructure and improve properties via surrounding IMCs by ductile eutectic phases.

Key Innovations:

- Qualification-aware process maps of scalable FGMs
- High-fidelity mesoscale simulations of FGM microstructures
- Properties resolved across intelligent functional gradients

Potential Impact:

This ESI award will dramatically advance the state-of-the-art in scalable manufacturing of AM-FGMs.

- Scalable manufacturing of propulsion and cryogenic fluid management systems remains a major challenge for space applications.
- For example, combustion devices must reject heat and maintain adequate structural margins under high pressures.
- Advances in AM-FGMs will allow for enhance NASA design functionality and reduce the likelihood of interfacial failures.