Scalable Hybrid Manufacturing of Bimetallic Components for Space Applications

PI: Wei Xiong, Materials Science, University of Pittsburgh
Co-I: Albert To, Mechanical Engineering, University of Pittsburgh
Co-I: Michael Klecka, Raytheon Technologies Research Center

University of Pittsburgh

Raytheon Technologies

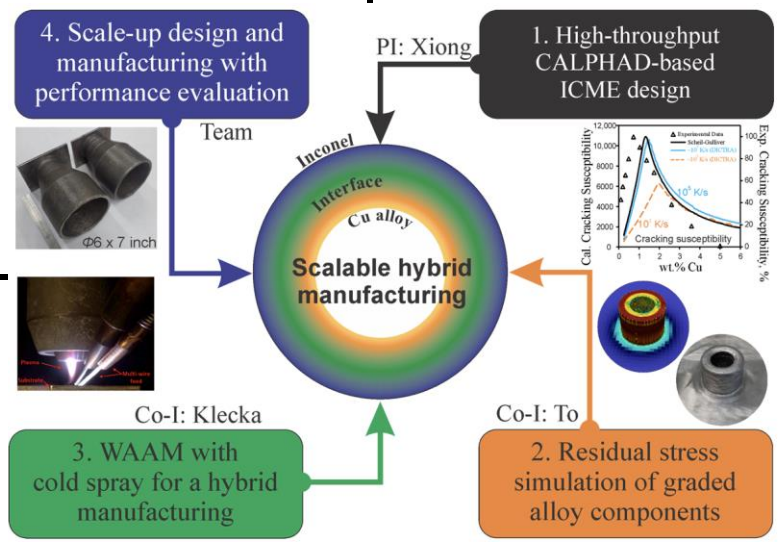
Research Objectives

Accomplish: The team aims to solve the crack formation issue of graded alloy printing from Cu alloy to Inconel alloy for channel wall nozzle applications.

Innovations: (1) High-throughput materials modeling will be coupled with advanced GPU-accelerated thermomechanical process modeling to predict the phase stability, solidification cracking susceptibility, residual stress, and coefficient of thermal expansion as a function of processing condition.
(2) Cold spray will be used to serve as a hybrid manufacturing solution to support WAAM as mitigation to avoid detrimental phase formation.

Compare to SOA: The team will apply advanced high-throughput modeling based on a multicomponent materials database for interface design.

TRLs: Start from TRL 2 and target TRL 4.



Project team and research content

Research Approach

High-throughput CALPHAD-based ICME design will be applied to determine the gradient interface composition profile in the bimetallic print.

Residual stress simulation will be performed to design the processing using the GPU technology, together with adaptive remeshing and matrix-free techniques. Both modeling effects will guide and optimize *the multi-material WAAM process* at RTRC.

Model calibration will be performed through *scale-up printing with uncertainty quantification* of process-structure-property relationships. If the detrimental phases are identified after the printing and cannot be eliminated during the post-heat treatment design, the ***cold spray of an intermediate layer*** designed by the CALPHAD-based modeling will be introduced.

Potential Impact

The proposed research uniquely integrates computational materials and mechanical design with manufacturing innovation to identify an effective method for scalable functionally graded materials printing.

The proposed effort directly supports the NASA LCUSP program, and the developed techniques can be directly applied to rocket engine component manufacturing for NASA missions. More broadly, the methods used for dissimilar alloy interfaces can be transitioned to the design of multi-principal element alloys. The technology developed can be applied to the design and manufacture of multifunctional components requiring both thermal and structural performances. Additionally, it can be utilized to design and produce architected metamaterials that can be treated as a type of new material.