I/UCRC Executive Summary - Project Synopsis	**Date**: April 2022
Center/Site: CANFSA/Colorado School of Mines	
Tracking No.:36G: Control of Microstructure During Additive Manufacturing of Ni Alloys	**E-mail:** rbochoa@mines.edu
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Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Ruben Ochoa	**Proposed Budget**: $320K (Leveraged)
Project Description: Additive manufacturing (AM) shows promise of reducing material waste, increasing energy efficiency, and yielding higher complexity parts. This project is focused on understanding the effects of solidification parameters on the microstructural evolution of Ni-based superalloys under AM conditions.	
Experimental plan: In-situ synchrotron x-ray radiography of laser spot welds and raster scans were collected at the Advance Photon Source (APS) to capture solidification velocities. Experiments varied with different Ni alloys, baseplate morphologies, powders, inoculated powders, laser powers, and laser speeds. Experimentally measured velocities will be coupled with modeled thermal gradients via the computational fluid dynamics (CFD) software, Flow3D. The resulting microstructures produced by APS experiments will be analyzed through Electron Backscatter Diffraction (EBSD) and other characterization techniques.	
Related work elsewhere: This project is a part of the ONR MURI, having AM focused research being conducted at various other universities.	
How this project is different: Studies found in the literature are focused on the analysis and modeling of industrial alloys. This project is focused on developing fundamental understanding of solidification behavior through systematic testing of various alloys, microstructures, and processing conditions.	
Milestones for the current proposed year: Develop a solidification processing map of Inconel 718, comparing the effects of base plate grain morphologies to those produced by the addition of powders with inoculants intended to promote grain refinement. Create and validate a columnar to equiaxed transition model based on EBSD, in-situ imaging, and modeling results.	
Deliverables for the current proposed year: Tune Flow3D simulations to better match experimental melt pool shapes. Introduce a powder layer to Flow3D simulations. Analyze grain morphologies of Inconel 718 raster scans at other power levels and laser speeds. Present at Additive Manufacturing Powder Metallurgy conference.	
How the project may be transformative and/or benefit society: An understanding of microstructural development under AM conditions will help to eliminate hot cracking and solidification texture. In turn, this will promote mechanical properties and isotropic behaviors comparable to traditional means of manufacturing.	
Research areas of expertise needed for project success: Solidification, inoculation, crystallography/texture, phase transformations, x-ray radiography, CFD, and EBSD.	
Potential Member Company Benefits: The development of AM parts with desirable mechanical properties and isotropic behavior will increase energy efficiencies while decreasing material waste. It will also increase production capability of complex geometries and reduce lead times.	
Progress to Date: Characterization of grain structures and morphologies of Inconel 718 raster scans at 216 Watts were completed. Raster scans included columnar base grains with powder, columnar base grains with inoculated powder, and inoculated base material with inoculated powder. Solid-liquid interfaces in APS radiographs were tracked and converted to velocities. Initial melt pool simulation of an Inconel 718 spot melt was created by Flow3D.	
Estimated Start Date: Fall 2021	**Estimated Knowledge Transfer Date**: Spring 2025

The Executive Summary is used by corporate stakeholders in evaluating the value of their leveraged investment in the center and its projects. It also enables stakeholders to discuss and decide on the projects that provide value to their respective organizations. **Ideally, the tool is completed and shared in advance of IAB meetings to help enable rational decision making.**