I/UCRC Executive Summary - Project Synopsis	**Date**: October 2021
Center/Site: CANFSA/Colorado School of Mines	
Tracking No.: 36E: In-Situ Characterization of Microstructural Evolution During Simulated Additive Manufacturing in Model Alloys	**E-mail :** brodgers@mines.edu **Phone :** (720) 413–4542
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Brian Rodgers	**Proposed Budget**: 320K, Leveraged

Project Description: Conduct spot melts and rasters of Al-Ag and Ni-Al-Mo samples at the Advanced Photon Source (APS) with in-situ radiography imaging. This will be coupled with ex-situ simulations of the melt pools correlated to the APS melts pools to verify solid-liquid interface velocities and obtain information about thermal gradients. Solidification velocities from APS radiography and thermal gradients obtained from simulations will be combined with microstructural characterization to assess solidification behavior of materials under different conditions. Analysis of Al-Ag samples will be augmented with DTEM.

Experimental plan: As-solidified samples of Al-Ag and Ni-Al-Mo from the APS will sectioned and imaged with SEM. TEM of FIB lift-outs and EBSD will serve as complementary analyses for regions of interest. TEM will also be used for DTEM samples. Simulations will be done with the FLOW-3D software package.

Related work elsewhere: This project is a part of an ONR MURI, so similar work is being conducted at other university sites, mainly on alloys from the INCONEL series and Ti-6Al-4V. These other projects also focus on electron beam additive manufacturing, while also using complementary APS experiments.

How this project is different: Other studies emphasize the analysis of built parts in industrial alloy systems, while this project is centered around model alloys. The goal is to understand fundamental solidification behavior, rather than analyzing the performance of a single alloy under specific conditions.

Milestones for the current proposed year: SEM and EBSD analysis of sectioned material. Further analysis of dendrite orientation transition in the Al-Ag and Al-Ge systems. Residency at LANL.

Deliverables for the current proposed year: Top-down images of microstructures in Al-Ag and Ni-Al-Mo APS samples, SEM and EBSD of the melt pool and raster cross-sections, simulations to determine thermal gradients in APS melt pools, and correlation of simulations to real melt pool shapes to ensure accuracy.

How the project may be transformative and/or benefit society: Most solidification research has been performed on slow solidification velocity scenarios such as casting. A deeper understanding of the phenomena uniquely seen at high velocities and gradients will facilitate advanced technologies, such as additive manufacturing to expand into more alloy systems. These results may also facilitate concepts for alloy design for additive manufacturing. Control of solidification conditions may lead to opportunities for producing unique microstructures, such as additive manufacturing of highly textured, or 'single crystal', parts. Knowledge of dendrite orientation transition may be leveraged to create novel microstructures. The results from this work will also be used to inform phase-field model development for rapid solidification by Prof. A. Karma's group at Northeastern University.

Research areas of expertise needed for project success: Beamline access for *in-situ* experiments. TEM of FIB lift-outs, SEM with EBSD, and post-processing to evaluate microstructure. FLOW-3D software for simulations of melts pools seen at APS.

Potential Member Company Benefits: Enhanced understanding and control of metallurgical behavior under rapid solidification conditions, with applications in additive manufacturing and laser welding.

Progress to Date: A matrix of Al-Ag and Ni-Al-Mo alloys underwent simulated additive manufacturing experiments with processing parameter variations at the APS. Completed top-down SEM imaging. Beginning of EBSD and continuing TEM analysis and preparation for analysis of sectioned samples.

Estimated Start Date: Fall 2019	**Estimated Knowledge Transfer Date**: Spring 2023

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.**