I/UCRC Executive Summary - Project Synopsis	**Date**: 9/10/2018

Center/Site: Center for Advanced Non-ferrous Structural Alloys (CANFSA)/ Colorado School of Mines

Tracking No.: Project 36-L: Rationalization of Liquid/Solid and Solid/Solid Interphase Instabilities During Thermal – Mechanical Transients of Metal Additive Manufacturing	**Phone :** (303) 990-0939	**E-mail :** asaville@mymail.mines.edu

Center/Site Director: CANFSA/M. Kaufman/P. Collins/Amy Clarke	**Type: New**
Project Leader: Alec Saville	**Proposed Budget**:$320K

Project Description: Solidification behavior in additive manufacturing (AM) has been proven to be more complex than standard casting solidification behavior, due to the evolution of spatial and thermal transients evolving during a build process. Here, instabilities during solidification and microstructural evolution of electron beam melted Ti-6-4 and Inconel 718 are being analyzed to gain a better insight into how temperature gradients, solute dispersion and other factors play into solidification behavior and ultimately material performance. Primarily fundamental research, this project aims to identify key areas of interest in additive manufacturing processes that can be further explored to refine the properties and performance of materials made via this method. This project is part of a Multidisciplinary University Research Initiative (MURI) involving five universities, the US Navy, and the Australian DOD.

Experimental plan: To evaluate the influence of spatial and temporal instabilities, several experiments are planned and/or already underway. Texture analysis via neutron diffraction at the HIPPO neutron diffraction beamline at Los Alamos National Laboratory and surface roughness/surface relief investigations via laser optical spectroscopy, and light optical microscopy via a Keyence 5000 housed at the Colorado School of Mines (CSM) are in progress. Simulating AM conditions with the Advanced Photon Source (APS) AM simulator and observing solidification behavior *in-situ* of Ti-6-4, Inconel 718, and/or appropriate surrogate materials, micro-CT scans to look at defect formation, and x-ray tomography using laboratory imaging systems soon to be deployed at CSM are planned. Neutron slit-texture analysis is also planned to relate local texture to different scan strategies employed during the AM build process.

Related work elsewhere: Other institutions involved in the MURI will be supporting this project with simulations, *ex-situ* acoustic analysis, and developing new techniques for *in-situ* transmission electron microscopy (UT, Virg-Tech, OSU, ISU), for example.

How this project is different: This project focuses on the characterization of resultant AM microstructures, instead of developing new analysis techniques, and deploys many novel characterization techniques to elucidate more about the evolution of instabilities during solidification.

Milestones for the current proposed year:

- Finishing preliminary literature review of Ti-6-4, Inconel 718, and the AM processes
- Finishing of surface roughness and surface relief measurements via light optical microscopy and laser spectroscopy
- Refinement of neutron diffraction data and development of code to process texture results

Deliverables for the current proposed year: A CANFSA project report and presentation will be delivered at the Fall 2018 CANFSA meeting. The MURI project kick-off meeting will also be attended in October 2018 in Oak Ridge, TN.

How the project may be transformative and/or benefit society: Qualification of AM materials is highly needed for the production of parts; rationalizing instability evolution will provide a new level of insight into phase transformation-microstructural evolution-processing relationships.

Research areas of expertise needed for project success: Texture and neutron diffraction, *in-situ* solidification characterization, laser spectroscopy, titanium and nickel alloy phase transformations, AM processing and parameters, and x-ray and micro-CT analysis.

Potential Member Company Benefits: Rationalization of interfaces will lead to drastic improvements in AM production and qualification for producing parts, ideal for aerospace and performance-driven applications.

Progress to Date: Initial testing of laser optical spectroscopy for surface roughness; initial light optical microscopy surface roughness analysis; neutron diffraction texture measurements; ongoing Rietveld refinement.

Estimated Start Date: 08/01/2018	**Estimated Knowledge Transfer Date**: May 2022

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.**