I/UCRC Executive Summary - Project Synopsis	**Date**: April 2020

Center/Site: CANFSA/Colorado School of Mines

Tracking No.: 36C-L: Combining *In-Situ* and *Ex-Situ* Characterization to Understand Crystallographic Texture Development in Metal Additive Manufacturing	**Phone:** (352) 281-5752	**E-mail:** jklemmto@mines.edu

Center/Site Director: M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Jonah Klemm-Toole	**Proposed Budget**: $100,000 Leveraged

Project Description: The emergence of metal additive manufacturing (MAM) has unlocked the possibility to create complex geometries with location and orientation specific properties. The vast parameter space available in MAM provides the opportunity to create unique microstructures that are not possible with conventional processing. Recent reviews by the Federal Aviation Administration and National Institute for Standards and Technology have identified anisotropic mechanical properties as a characteristic of MAM that limits the broad implementation of this transformative technology. Crystallographic texture, or the non-random orientations of grains, is expected to be a major contributor to anisotropic mechanical properties observed in MAM. In this project we aim to combine i*n-situ* characterization, e.g. X-ray radiography during laser melting to simulate laser-based MAM, with *ex-situ* characterization such as scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD) to understand crystallographic texture development in MAM. It is expected that the outcome of this project will contribute to a deeper understanding of processing-microstructure relationships and enable the broader implementation of MAM.

Experimental plan: Single crystal samples with specific crystallographic orientations made from two model Ni-based superalloys will be laser melted at the Advanced Photon Source (APS), while obtaining *in-situ* X-ray radiography to measure the velocity of the solid-liquid interface. *Ex-situ* EBSD and SEM will be used to characterize the solidification microstructure. Combining *in-situ* and *ex-situ* characterization will allow for the estimation of dendrite/cell tip velocity that will be used to calibrate heat transfer models to better understand the columnar to equiaxed transition (CET) in Ni-based superalloys.

Related work elsewhere: Similar work is being performed by Tresa Pollock's group at University of California Santa Barbara (UCSB), in collaboration with CANFSA through an Office of Naval Research (ONR) Multi-Disciplinary University Research Initiative (MURI).

How this project is different: This project is focused specifically on crystallographic texture and the disruption of texture through the CET in model Ni-based superalloys. The UCSB group is focused on more industrially-based Co-Ni alloys and Inconel 718.

Milestones for the current proposed year: In the current proposed year, the second set of experiments were conducted at the APS, and the results were presented at TMS2020.

Deliverables for the current proposed year: A journal publication documenting the findings of the first and second set of experiments at the APS is planned in the current year.

How the project may be transformative and/or benefit society: The outcome of this project will contribute to a deeper understanding of processing-microstructure-property relationships and enable the broader implementation of MAM to high value, failure critical components such as gas turbine airfoil components.

Research areas of expertise needed for project success: Radiography, image processing, EBSD, SEM, computational modeling.

Potential Member Company Benefits: Increasing the depth of understanding of processing-microstructure-property relationships is expected to help CANFSA member companies expand MAM into more demanding applications, and is of interest to the DoD.

Progress to Date: The first two sets of experiments are complete, radiography analysis is nearly complete, EBSD and SEM is nearly complete, MS&T and TMS presentations have been delivered.

Estimated Start Date: Spring 2019	**Estimated Knowledge Transfer Date**: Fall 2020

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.**