I/UCRC Executive Summary - Project Synopsis	Date: April 2022
Center/Site: CANFSA/Colorado School of Mines	
Tracking No.: 36F Microstructure and Processing Links in Beta-Titanium during Additive Manufacturing	**E-mail:** jasien@mines.edu **Phone:** (951) 216-5804
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Chris Jasien	**Proposed Budget**: $320K, Leveraged

Project Description: This project focuses on investigating solidification and microstructure evolution of selected beta-titanium alloys during additive manufacturing (AM). This includes understanding the columnar to equiaxed transition (CET) for a variety of thermal conditions, as well as thermal history effects on microstructure development. In-situ radiography experiments of laser-powder bed fusion processing (L-PBF) of Ti-10V-2Fe-3Al, a beta-titanium alloy, allows for the determination of solid-liquid interface velocities for various solidification conditions. In conjunction with these velocities, finite element analysis (FEA) simulations using tools such as *FLOW-3D* provide other values like thermal gradient to fully understand the effect of processing conditions on as-built microstructures. Investigation of other beta-titanium alloys for L-PBF and other AM processes is also planned as part of this project.

Experimental plan: In-situ radiography imaging of AM simulator experiments for Ti-10V-2Fe-3Al will be performed at the Advanced Photon Source (APS). Solid-liquid interface velocities will be extracted and coupled with thermal gradient calculations from simulations of the specific experiments. These values, along with SEM and EBSD imaging, will be used to link AM processing strategies to resulting microstructures.

Related work elsewhere: Work has been completed relating processing conditions to as-built microstructures for many titanium alloys, especially Ti-6Al-4V. Solidification maps have been developed for these alloys and used to predict grain morphologies based on AM processing conditions.

How this project is different: Processing of beta-titanium alloys using AM has yet to be been investigated extensively for structural applications. Little is known about influence of AM process conditions on this alloy system's solidification behavior and resulting microstructures. Additionally, simulation tools have not been used to attempt to model beta-titanium subjected to AM conditions.

Milestones for the current proposed year: Completion of cross-section EBSD for specimens of interest, complementary simulation work, and initial experiments on crack-susceptibility of AM produced parts using Sigmajig testing.

Deliverables for the current proposed year: EBSD of selected APS samples, predicted solidification conditions using simulation tools, and publication of melt-pool modeling work.

How the project may be transformative and/or benefit society: Investigation of microstructure evolution during AM allows for greater understanding of beta-titanium that will advance this field and may provide strategies for AM alloy design. Simulation work also develops a procedure for obtaining/populating missing material property data needed to conduct accurate and useful simulations.

Research areas of expertise needed for project success: Simulation tools, SEM and EBSD imaging and post-processing, thermodynamics, and titanium metallurgy.

Potential Member Company Benefits: The microstructure and processing-links for AM produced beta-titanium is of interest to those in the aerospace and defense sectors. Other members working with AM will also benefit from aspects of the simulation work.

Progress to Date: Velocity extraction and top-down SEM imaging for all APS experiments, simulation calibration and initial processing of predicted solidification conditions, and development of L-PBF Sigmajig test chamber.

Estimated Start Date: Fall 2020	**Estimated Knowledge Transfer Date**: Spring 2024