

I/UCRC Executive Summary - Project Synopsis**Date:** March 2019**Center/Site:** CANFSA/Colorado School of Mines**Tracking No.:** 14
Characterization of Regions in Ti-6Al-4V Forging with Diminished Ultrasonic Inspectability**Phone :** (303) 273-3770**E-mail :**
concampb@mymail.mines.edu**Center/Site Director:** M. Kaufman/P. Collins/A. Clarke**Type:** Continuing**Project Leader:** Connor Campbell**Proposed Budget:** \$240,000

Project Description: Outliers caused by microstructural inhomogeneities are found all throughout the titanium forging industry. Industrial thermomechanical processes are designed to suppress these inhomogeneities, but the inherent anisotropy alpha/beta titanium alloys– particularly the lamellar microstructure produced by cooling from above the beta transus– makes these structures difficult to homogeneously deform in a reliable fashion. Soft oriented colonies can provide a path for shear to localize, complicating the breakdown process intended to produce a uniform microstructure. This project seeks to characterize Ti-6Al-4V samples donated from Weber Metals with low ultrasonic quality, analyzing aspects of the microstructure that contribute to poor inspectability and proposing methods to mitigate them.

Experimental plan: Samples were extracted from regions that produced ultrasonic signals during nondestructive inspection. Backscattered electron images were taken of various features at depths indicated during inspection and orientation maps were extracted via electron-backscatter diffraction for Taylor factor and slip transmission analysis in order to glean insight into the persistence of these features.

Related work elsewhere: There has been a significant volume of research conducted on localized heterogeneous deformation in alpha/beta Ti alloys, and the effects of process parameters on the resultant microstructure, and therefore inspectability, of titanium forgings.

How this project is different: This study seeks to quantify aspects of microstructural features found at depths detected during ultrasonic inspection. Previous works have focused on the general microstructure and correlation with ultrasonic signals, but have not produced datasets that can be used for physics-based models.

Milestones for the current proposed year: Completing analysis of the microstructures that produced relatively high backscattered ultrasonic signals, and submitting the final report of the project in the form of a MS thesis.

Deliverables for the current proposed year: Microstructures of high- and low- ultrasonic quality regions, and relevant data including grain size and shape measurements as well as Taylor-factor and slip transfer analysis to determine how to discourage their formation.

How the project may be transformative and/or benefit society: Knowledge of how microstructural heterogeneities form will allow production to be optimized in order to avoid them, increasing performance of titanium producers and reducing probability of rejection due to microstructural inhomogeneity.

Research areas of expertise needed for project success: Metallurgy of alpha/beta titanium alloys, industrial forging practices, electron microscopy, orientation imaging analysis, crystal plasticity modeling

Potential Member Company Benefits: Enhanced understanding of conditions that lead to microstructural heterogeneity may provide insight into how to avoid it, increasing mechanical and fatigue response as well as ultrasonic inspectability.

Progress to Date: Compression experiments have been completed, and multiple samples have been characterized. Initial orientation maps have shown alpha colonies deforming heterogeneously, and colonies in various states of geometric dynamic recrystallization. Regions with low ultrasonic quality have been imaged and orientation maps have been obtained in addition to bulk texture measurements obtained via X-ray diffraction.

Estimated Start Date: Spring 2016**Estimated Knowledge Transfer Date:** May 2019

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.**