I/UCRC Executive Summary - Project Synopsis		Date:
Center/Site: CANFSA/Colorado School of Mines		
Tracking No.:30-L: Microstructural Evolution of Metallic Alloys during Rapid Solidification	**Phone :** (843) 618-7968	**E-mail :** chloejohnson@mymail.mines.edu
Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke		**Type: (Continuing)**
Project Leader: Chloe Johnson		**Proposed Budget**: $240,000

Project Description: Solidification conditions can determine the final microstructure and properties of a metallic alloy. Because of this, understanding microstructural evolution during solidification is paramount to optimizing final properties of a metallic component. This is especially important for far from equilibrium processing and complex thermo-mechanical cycling, where microstructural characteristics such as phase stability, metastable phases, and grain morphology can evolve to impact properties and performance. In this work, in-situ and post-mortem studies of aluminum alloys during/after rapid solidification will be performed to understand microstructural development, which is relevant for processes like additive manufacturing.

Experimental plan: In-situ imaging techniques, along with post-mortem characterization, will be used to evaluate metastable phases and microstructural characteristics for different binary and ternary aluminum alloys (namely Al-Cu, Al-Ag, Al-Ge, and Al-Cu-Ag). Aluminum powders containing ceramic inoculants will also be studied to explore grain size control during rapid solidification.

Related work elsewhere: Some studies have been performed by our group and collaborators using Dynamic Transmission Electron Microscopy (DTEM) to capture Al-Ge solidification and Al-Cu and Al-Si alloy rapid solidification. Other work in this area is limited and has mostly focused on post-mortem evaluations of binary aluminum alloys (e.g. Al-Mn, Al-Ge, Al-Cu). Rapid solidification of ternary alloys, particularly in-situ characterization, remains largely unexplored. Our group has also performed in-situ imaging of various Al alloys during directional solidification to date.

How this project is different: Previous studies of microstructural development during rapid solidification have mostly been limited to post-mortem characterization of select binary aluminum alloys such as Al-Cu, Al-Ge, and Al-Mn. This project will focus on in-situ characterization of binary and ternary aluminum alloys, as well as aluminum alloy MMC powder. In-situ and ex-situ characterization will enable improved understanding of phase transformations and microstructural development during rapid solidification conditions relevant to additive manufacturing.

Milestones for the current proposed year: Multi-scale, in-situ and ex-situ experiments will be performed to further our understanding of microstructural development in Al alloys as a function of processing.

Deliverables for the current proposed year: DTEM has been performed at Lawrence Livermore National Laboratory (LLNL) on Al-Ge and Al-Ag alloys. We also plan to perform in-situ imaging of select Al alloys and powders with an additive manufacturing simulator at the Advance Photon Source at Argonne National Laboratory. Melt spinning is currently being pursued at Mines to capture a broader range of solidification and microstructural conditions.

How the project may be transformative and/or benefit society: Understanding how rapid solidification affects final microstructures and properties is important for processes like additive manufacturing and for developing process and microstructural models.

Research areas of expertise needed for project success: Solidification; solid-state phase transformations; microstructural development; in-situ imaging; advanced electron microscopy; materials processing; additive manufacturing

Potential Member Company Benefits: The fundamental knowledge gained from this project will be applicable to Al and other metallic alloys to help predict and control final microstructures and properties for processes where far from equilibrium conditions are encountered.

Progress to Date: Literature review has been performed to select alloys for rapid solidification experiments. A first round of DTEM has been performed at LLNL on Al-Ge and Al-Ag alloys. Post-mortem characterization is underway on previously performed DTEM experiments. Melt spinning is being pursued, and some initial laser welding experiments at CSM have been performed.	
Estimated Start Date: Fall 2017	**Estimated Knowledge Transfer Date**: Spring 2021

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.**