I/UCRC Executive Summary - Project Synopsis	**Date**: October 2nd, 2018

Center/Site: CANFSA/Colorado School of Mines

Tracking No.:31: Accumulative Roll Bonding of Al and Ti Sheets Toward Low Temperature Superplasticity	**Phone :** (503)866–6530	**E-mail :** bmcbride@mines.edu

Center/Site Director: CANFSA/M. Kaufman/P. Collins/A. Clarke	**Type: (Continuing)**
Project Leader: Brady McBride	**Proposed Budget**: $240,000 Leveraged

Project Description: Accumulative roll bonding (ARB) is a severe plastic deformation technique used to produce ultrafine grained materials with a convention rolling mill. This processing technique has shown significant Hall-Petch strengthening behavior and enhanced superplastic formability. Materials subject to ARB exhibit typical superplastic behavior at reduced temperatures and increased strain rates, which has the potential to significantly impact the cost and processing time of superplastic sheet forming. This project investigates the temperature dependence of superplastic forming of materials produced using ARB.

Experimental plan: An ARB process will be developed at the Colorado School of Mines with existing equipment to gain a fundamental understanding of the process using aluminum alloys. The mechanical properties of ARBed material will be characterized at room and elevated temperatures to explore strengthening and superplastic responses. Microstructural evolution, texture and bonding interface development will be explored in detail to develop a comprehensive understanding of the ARB process. After a reliable process is established, different alloy systems, including titanium alloys, will be explored.

Related work elsewhere: The majority of previous work has been focused on proof-of-concept studies pertaining to ARB. Research has been conducted for the past decade at Osaka University of Japan on the development of the ARB process and processing parameters that effect grain refinement. Similar work has been conducted out of the Isfahan University of Technology in Iran. Los Alamos National Laboratory has been studying the ARB process for producing nanolamellar metallic composites.

How this project is different: Few studies have examined the superplastic behavior of ultrafine grained materials produced by ARB. Recent developments have proven the enhancement of superplastic behavior, but have not comprehensively studied this behavior in specific alloy systems. The limits of ultrafine grained superplastic behavior for any given alloy have yet to be fully characterized or optimized. This project will extensively study the influence of processing parameters on superplastic formability and will fully characterize the observed superplastic behavior in select alloys.

Milestones for the current proposed year: Explore the full capabilities of ARB by working with aluminum alloy systems, such as 5083, 5182 and 5754. Characterize room temperature and elevated temperature mechanical properties of roll bonded aluminum alloys. Develop methodologies to measure roll bonding strength and investigate which processing parameters optimize bond strength. Gain experience in methodologies (electron backscatter diffraction (EBSD) and transmission electron microscopy (TEM)) used to characterize microstructural development.

Deliverables for the current proposed year: Room and elevated temperature tensile data of ARBed aluminum alloys, such as 5083, 5182 and 5754 will be obtained. An investigation of microstructure refinement (i.e. grain size) through ARB processing will be performed. A summary of roll-bonding process parameters that affect bond strength, primarily focusing on the effects of preheating and post-deformation heat treatments will be performed.

How the project may be transformative and/or benefit society: An in-depth understanding of ARB will be developed with respect to multiple aspects (microstructural refinement, texture development, strengthening, superplasticity, strain rate sensitivity) in select alloys. This will act as a detailed case study to showcase the full potential of ARB as a novel processing method and its benefit to industry. The research provided will serve as a baseline for the development of ARB processes in other alloy systems.

Research areas of expertise needed for project success: Access to a high capacity rolling mill (>50 tons) is vital for producing samples that are wide enough to minimize edge cracking. This will become extremely important if titanium alloys are studied. Knowledge of sub-sized mechanical testing techniques and sub-micron scale microstructural characterization techniques, such as TEM, will be needed.

Potential Member Company Benefits: Enhanced superplasticity by means of reduced temperature or increased strain rate has the potential to increase cycle time of forming operations while reducing costs. Cost reduction can be found in both reduced cycle time and reduced heating requirements. Superplastic forming at lower temperatures has the potential to reduce wear on forming dies.	
Progress to Date: The rolling mill at Colorado School of Mines has been upgraded with adjustable edge guides and a digital data acquisition system for measuring rolling loads. An ARB process has been developed to successfully roll bond Al 1100 with up to 8 repeated cycles. Fixtures have been designed and fabricated to rapidly machine tensile specimens in-house with CNC milling. Preliminary room temperature tensile tests have been conducted on ARB-processed Al 1100.	
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.**