I/UCRC Executive Summary - Project Synopsis		**Date**: April 3, 2018
Center/Site: CANFSA/Colorado School of Mines		
Tracking No.: 31-L Accumulative Roll Bonding of Al and Ti Sheets Toward Low Temperature Superplasticity	**Phone :** (503) 866 - 6530	**E-mail :** bmcbride@mymail.mines.edu
Center/Site Director: 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 behaviour at reduced temperatures and increased strain rates, which has the potential to significantly impact the cost and processing time of superplastic sheet formability. This project investigates the temperature dependence of superplastic forming of materials produced using ARB.

Experimental plan: Sheets of Al 2024 have been provided by Boeing for this study. The material will be subject to ARB and mechanical properties will be determined at both room and elevated temperatures to simulate superplastic forming. Material properties pertaining to observed mechanical behaviour, such as microstructural evolution, texture and bonding interface development, will be explored in detail to develop a wholesome understanding of the ARB process. Additional materials, including titanium alloys, will be explored in the future.

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 behaviour of ultrafine grained materials produced by ARB. Recent developments have proven the enhancement of superplastic behavior but have not comprehensively studied this behaviour in specific alloy systems. The limits of ultrafine grained superplastic behaviour 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 behaviour in select alloys.

Milestones for the current proposed year: Develop processing procedures that allow for adequate bonding during subsequent ARB cycles. Process specimens of Al 2024 and observe evolution of mechanical properties (UTS, YS, elongation) with respect to number of ARB cycles. Demonstrate low temperature superplasticity effects in Al 2024 subject to ARB by means of elevated temperature tensile tests.

Deliverables for the current proposed year: Room temperature tensile data exhibiting Hall-Petch strengthening aspects of ARB. Elevated temperature tensile data exhibiting superplastic effects of ARB processed material.

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, textural development, strengthening, superplasticity, strain rate sensitivity) in a few 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 high load capacity rolling mill for development of ARB samples, especially for titanium alloys. Knowledge of texture measurement and characterization techniques. Ability to quantify and characterize result bonding interfaces.

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: An understanding of bonding surface preparation has been developed in experimental roll bonding trails. Two subsequent ARB cycles have been produced in Al 6061 with adequate bonding confirmed with optical microscopy. This serves as a proof-of-concept for the rolling capabilities of the CSM rolling mill. Sheets of Al 2024 have been obtained for subsequent rolling trials.

Estimated Start Date: Fall 2017	**Estimated Knowledge Transfer Date**: Spring 2021