Rapid Synthesis and Characterization of Covetic Nano-materials

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Project Objective

- To provide insights to the following fundamental questions
  - Can covetic conversion take place without melting (under high density electric current)?
  - What about other form of energy, other than electric current?
  - What are the material systems in which the covetic conversion is possible, and the nature of the covetic conversion process?
- Elucidate the fundamentals of covetic conversion mechanisms through purposely designed experiments
- Explore and identify alternative approaches to rapid synthesis of covetic materials

Technical Innovation

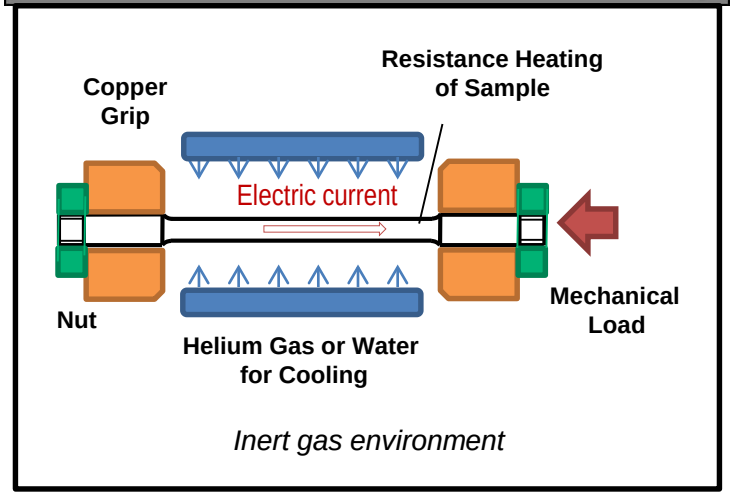
- Develop rapid synthesis methodologies that allows for quick evaluation of various process conditions and material systems for covetic conversion
  - Reduce the cost of discovery
- Innovation 1: Covetic materials by solid-state conversion
  - Will covetic conversion take place without melting, but under much higher electric current density?
- Innovation 2: Explore alternative forms of energy
  - Utilizing extensive material processing capability at national labs

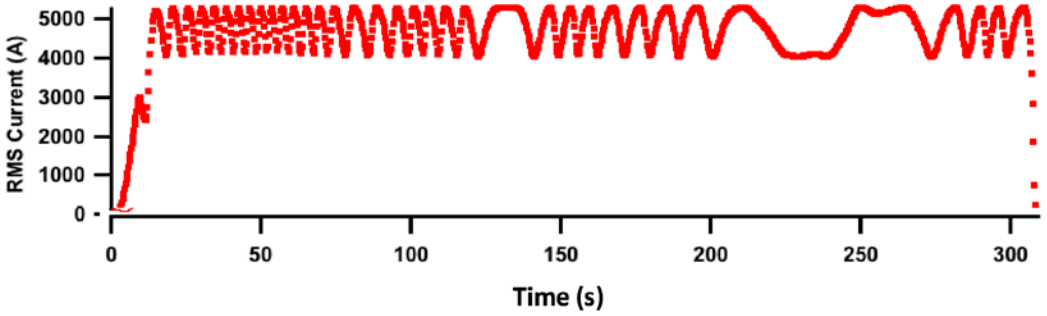
Technical Approach

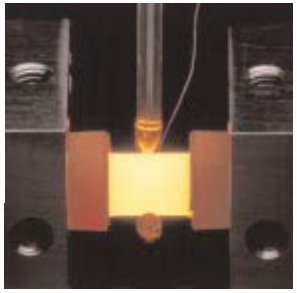
- Covetic materials by solid-state conversion
  - Will covetic conversion take place without melting, but under much higher electric current density?
  - Utilize Gleeble system to provide highly controlled environment for conversion
  - Effect of oxygen
  - Steel conversion
- Utilize alternative form of energy
  - Patent application pending
- Collaborate with NETL (cast mother alloys) and ANL (advanced characterization)
- Covetic materials are expected to have major impact in a number of industry applications. The project team at ORNL is experienced and uniquely positioned for commercialization of new materials and alloys for broad industry applications.

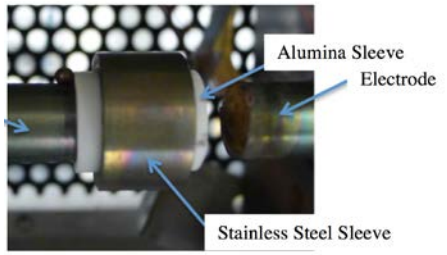
Results and Accomplishments

- Completed Gleeble based solid-state conversion process development (3/2016 Milestone)
  - Electric resistance heating and special cooling system for highly programmable control of heating and cooling conditions
  - A special control module was used to directly control electric current density during the experiment
  - Sustainable current density level of~6000A/cm² vs ~300A/cm² in literature



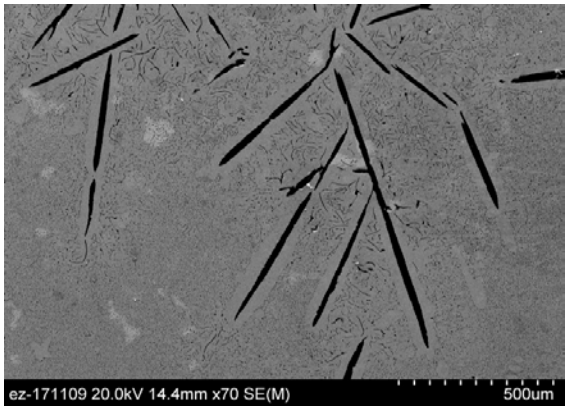


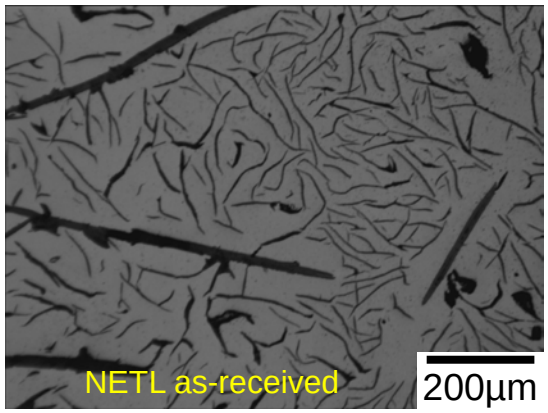




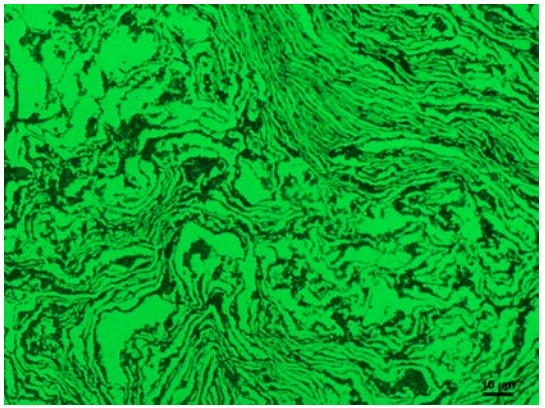
Results and Accomplishments

- Thermal properties obtained so far are promising

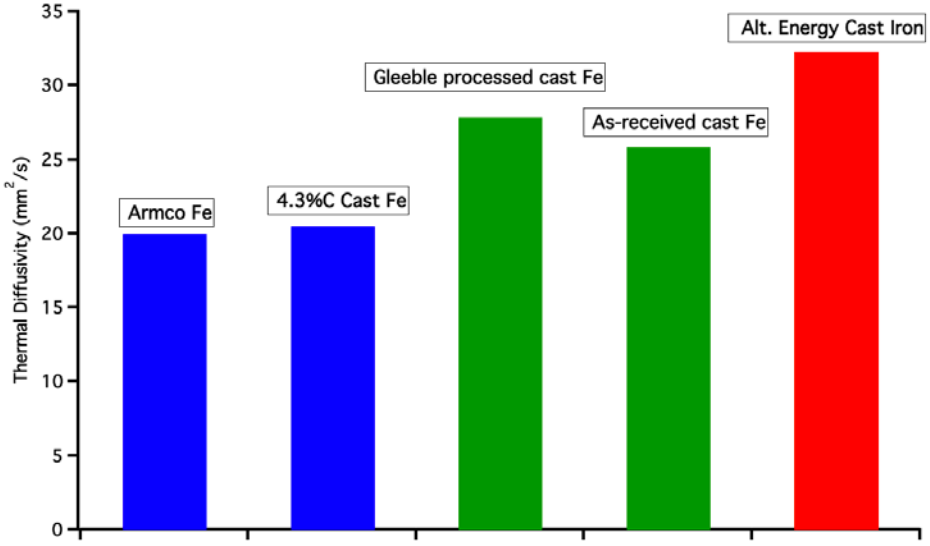


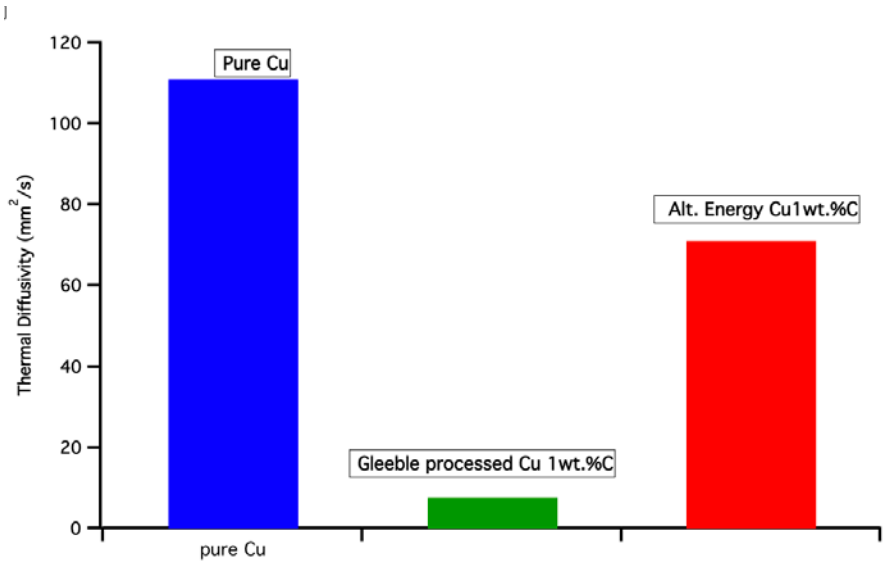


Cast Fe samples (4-5%wt C)



Gleeble processed Cu with 1%wt C nominal





Summary and Plan

- Investigate better ways to prepare feedstock materials for solid-state conversion process
  - Reduce/control the oxygen level in powder based process
  - New powder mixing and consolidation approaches
- Continue to explore alternative forms of energy for covetic conversion
- Microstructures characterization to identify the microstructure features that underlines the increased properties.
  - Microstructure in carbon added materials (especially Fe based) can be complicated, and potentially inhomogeneous.