Melt Processing of Covetic Materials

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Overview

Timeline

- First award in FY15
- First covetic melt July 2015
- Project on task
- Partnering with ANL in response to a lab call for FY19

Budget

	FY 17	FY 18
DOE Funded	1.3M	0.4M

Barriers

- The Key barriers this project include the difficulty of working with molten metal.
- Structure of the optimized material is on a fine scale.
- Uniformity of product.

Partners

- NETL and ANL have closely collaborated for several years on this project.
- NETL and ORNL have also collaborated in years past.
- NETL is an active participant in the bi-annual Covetic materials meetings for the past several years.

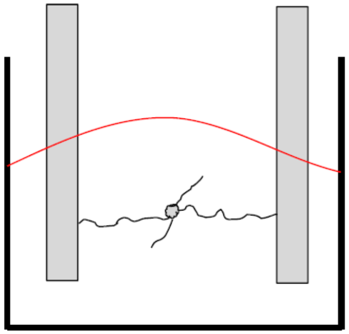
Project Objective

- The purpose of this research is to improve the melt processing of metal alloys with significant additions of integrally-bound nano-scale carbon phase (i.e., “covetic” nano-materials) in order to produce materials with consistent products and improved performance characteristics.
- What is the problem?
  - Previous research by the US Navy and Univ. of Maryland, verified that the principal claims of the unique structure and properties of covetic Al and Cu (alloys with integrally-bound nano-scale carbon precipitates with higher thermal and electrical conductivity and increased oxidation resistance). These unique alloys are attractive for numerous advanced energy applications (power transmission lines, motor windings, electrical contacts, heat-exchangers, etc)[1].
  - However, the process as-invented by others provides material of highly variable quality and compositional accuracy [2]. This resulted in variable performance characteristics. Thus, there is a needed for developing improved melt practices that produce consistent products for wide spread commercialization of these unique materials.
- Why is it difficult?
  - The process, as developed by others, is a non-traditional melt processing method (an electrical current is applied to the melt during induction melting).
  - There is lack of fundamental knowledge of the methodology, which needs to be developed in order to improve the process.
  - In order to ensure the transferred to industry, laboratory experiments need to be conducted at scales that easily translate to industrial practices.

[1] https://powerpedia.energy.gov/wiki/Covetic_Nanomaterials
[2] D. Forrest, “ONR Research Summary: Accelerating Insertion of Cu and Al Covetic Materials for Naval Applications,” 2012.

Technical Innovation

- Melt processing of covetic materials is far from an every day occurrence.
- Our approach is to independently replicate the "conventional" covetic conversion and evaluate materials conductivity performance.
  - Detailed records of the process
  - Evaluate critical parameters
- Explore alternative processing routes
- Create high conductivity alloys such as stainless steels and Ni-base alloys by alloying with covetic master alloys and/or alternate processing routes.



Technical Approach— Overarching Approach

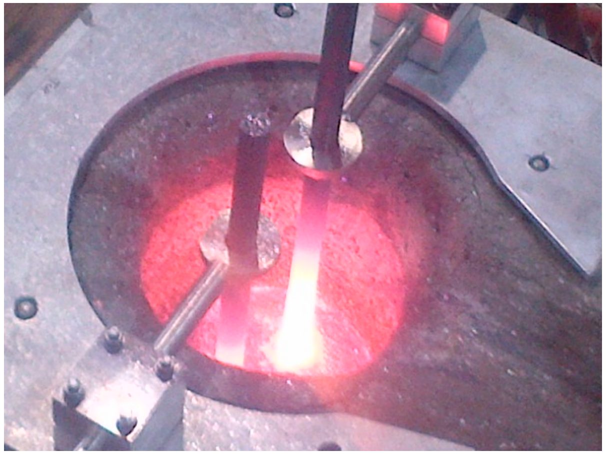
- NETL’s overall approach is to:
  - Replicate the induction melt methodology to produce these alloys and better understand and control critical variables
  - Utilize knowledge gained from the induction melt techniques in exploring alternate processing routes.
  - Create covetic alloys that would benefit from higher conductivity.
- NETL melted/fabricated covetic materials has been made available to ANL for advanced characterization.
- NETL has further melted/fabricated covetic materials initially processed by ANL and then returned these to ANL for advanced characterization.

Processing

Characterization

Technical Approach—Process Refinement

- Not many details of the present melt practice are know.
- Conceptually, a melt is formed in an induction furnace, carbon is added and current is applied between graphite electrodes within the melt.
- Our approach has been to replicate what is know of the established melt practice and extensively document our experiences including:
  - Temperature measurements
  - Form of carbon used
  - Current, voltage and hold times



Results and Accomplishments

- Progress thus far:
  - Open air covetic conversion unit fully operational.
    - Best results: Covetic 99.2% IACS vs 92% for conventional Cu.
    - Covetic copper IACS always has higher IACS compared to our conventionally made Cu
  - Produced covetic Stainless Steel via the alternative method.
    - Material has been melted and is in the que for processing and testing.
  - Produced covetic stainless from covetic-Fe feedstock using conventional alloy processing.
    - Material has been melted and is in the que for processing and testing.
  - Procurement of Specialized Furnace.
    - Furnace on site and installed.
    - Covetic components designed and on order.

- Informal monthly and formal quarterly reports submitted to document progress.

Transition (beyond DOE assistance)

- This project is important for meeting DOE clean energy goals including:
  - Improved/more efficient electrical distribution
  - Improved/more efficient transformer performance
  - Improved/more efficient heat exchangers
- Once demonstrated, the commercialization route will be to approach conventional alloy producers to illicit interest.
  - Presentations and publications will be made at relevant professional meetings such as ASM, AFS, TMS, and Specialty Metals Producers Consortium meetings.
- This technology is expected to have a market pull due to the unique properties solving a number of existing problems.

Questions?