A Direct Process for Wire Production from Sulfide Concentrates

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MIT
Dates TBD

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Overview

Timeline

- Award not issued as of July 2, 2018
- Projected End date TBD
- Project 0% complete

Barriers

- large scale and long operation to evaluate copper product purity
- management of concentrate impurities (Fe, S)
- Evaluate process for wire production

Budget

	FY 18 Costs	FY19 Costs	FY 20 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	685K	606K	602K	$856K
Project Cost Share	171K	152K	154K	480K

Partners

- MIT
- Contacts at Freeport McMoran, Rio Tinto, JX mining

Objectives

Simplify copper wire production for higher productivity, lower energy consumption

Problems/Barriers

- Principles for copper extraction is >5000 years old
- Sulfuric acid as a by-product
- Process has numerous steps with slow recovery for valuable elements

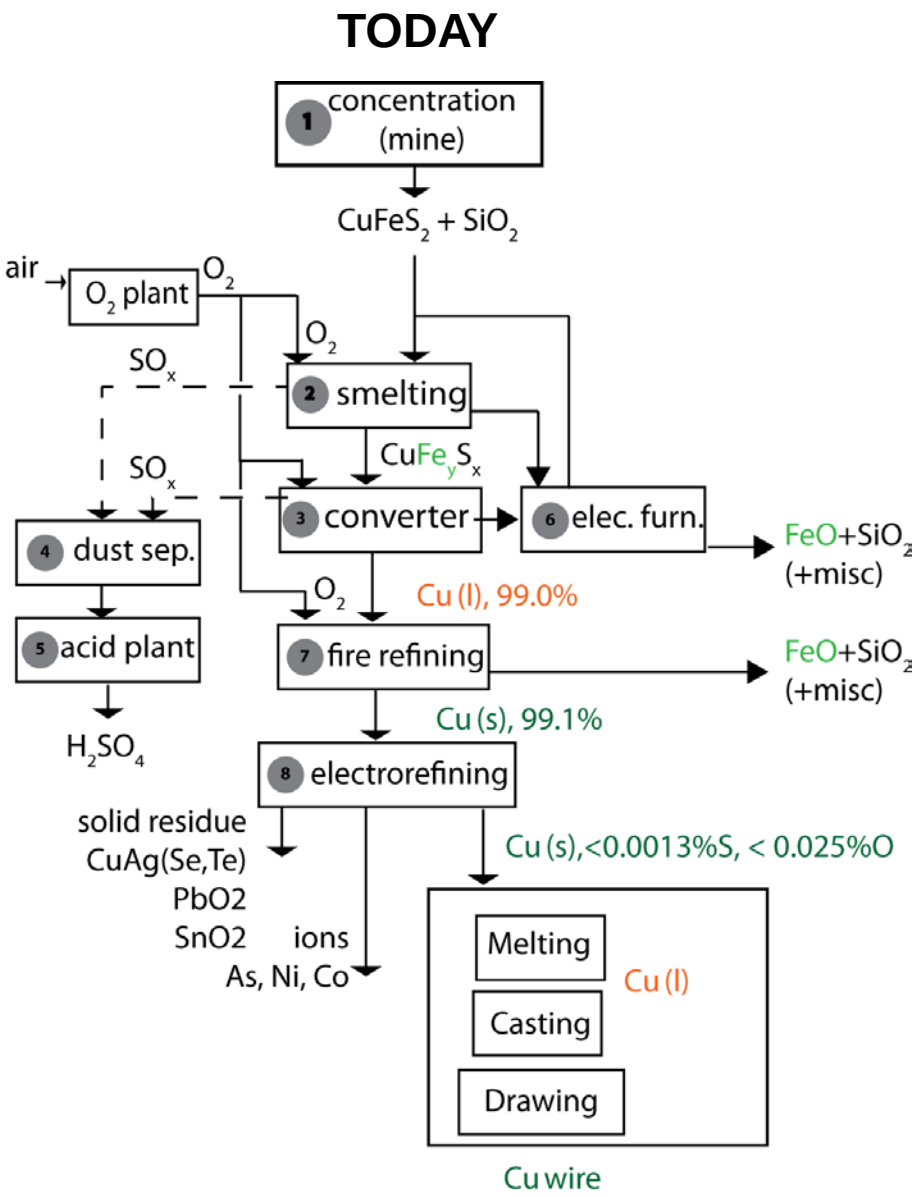
Energy use/manufacturing

- High energy consumption (3600kWh/t_{Cu})
- Low productivity from ore to metal wire
- Expected surge in demand for wires with further electrification
- Expected surge in demand for copper by-products (Te, Se, Mo, Ag…)

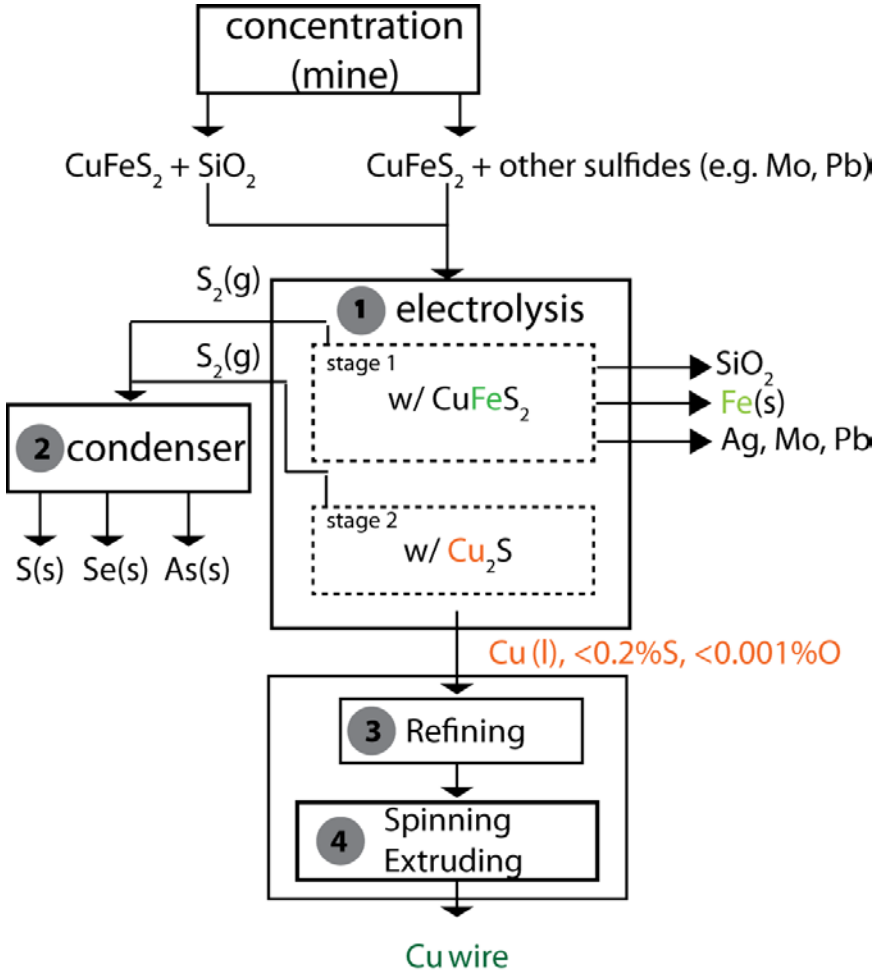
Objectives -> difficulty

- Evaluate copper purity at larger scale (several 10g) -> need larger reactor
- Decrease energy consumption by 5 to 20% -> need optimized electrolyte
- Demonstrate high productivity (6x Hall Heroult) -> need impurities management

Technical Innovation



Technical Innovation



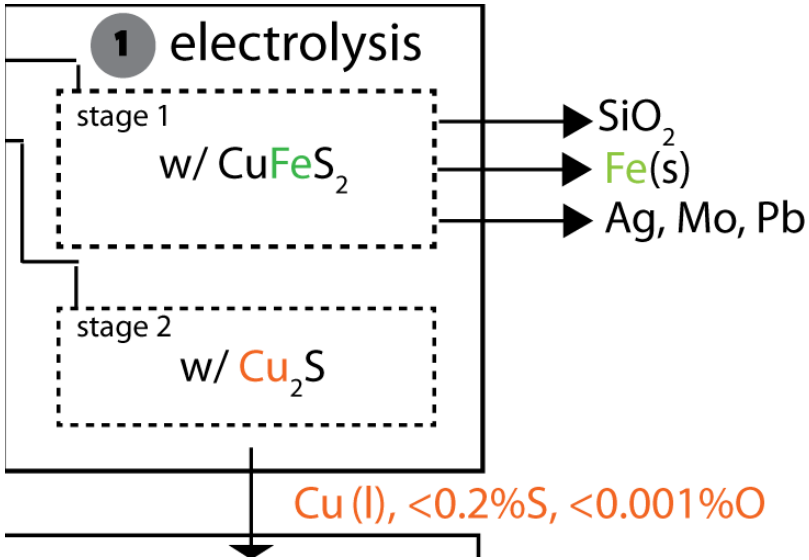
Molten Sulfide Electrolysis of Copper Concentrate

- Electrolysis reactor operates solely with electricity at 330kWh/t_{Cu}
- Same reactor principle applies to all elements from the concentrate (Fe, Mo, Ag… and S, As, Se, Te…) and make liquid copper
- Liquid copper is the last product, made in absence of oxygen, amenable to novel wire production processes

Technical Approach

Pursue in parallel electrolyte optimization, laboratory scale electrolysis , and process models to produce quantitative results that enable future pilot-scale deployements

- Verify if existing approaches are compatible with actual ore concentrates
- Produce sufficient amount of Fe, Cu and S for quantitative characterization (1t/y Cu capacity)
- Demonstrate path forward for handling Fe then Cu
- Evaluate possible Cu wire production process based on Cu product purity
- Provide design and operating parameters for 1t/day Cu pilot from concentrate



Technical Approach

MIT – Allanore Research Lab

Vision and competence to translate ideas into implementation

- innovative high temperature electrolysis for steel or rare-earth production
- demonstrated experience from materials processing fundamentals to engineering and reactor design and operation (ArcelorMittal pilot, MOE and MSE reactors at MIT)
- only laboratory in the world combining in-situ/containerless electrolysis of melts with advanced thermodynamic
- in-house reactor modeling (finite elements), design (CAD) and construction capability
- founder of Boston Electrometallurgical Corporation (BEMC)

MIT – Other supports

- Extrusion and mechanical machines construction for laboratory testing of selected copper products (Prof. Slocum)
- Advising researcher staff from experience in aluminium small-scale operation (Prof. Sadoway)

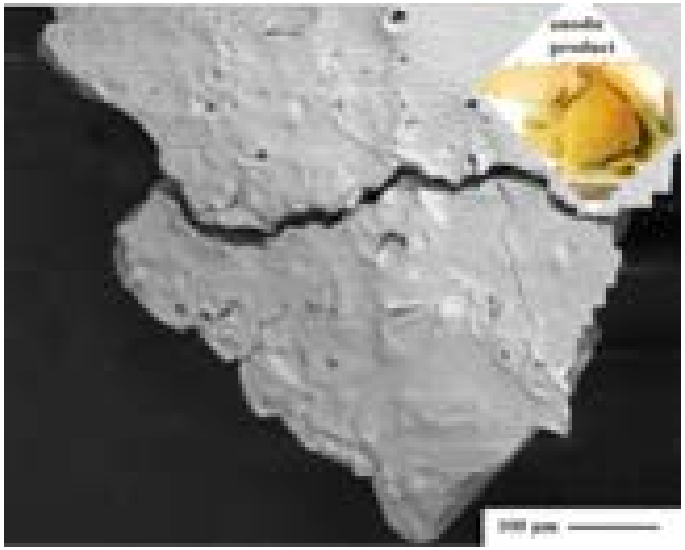
Results and Accomplishments

Project Status / Accomplishments

- Negotiation in progress with DOE-AMO
- Securing essential staff
- Inventory and preparation of purchases to be ready to test at the scale anticipated in Y1

In Hand Results

- Demonstrated 70% faradaic efficiency for liquid copper production from Cu_2S
- Cu purity greater than 99.9% (other impurities not detectable at the scale produced)
- Evolution of elemental sulfur demonstrated
- Confirmation of the low energy consumption from Cu_2S to elemental liquid Cu
- Identification of 5 electrolyte components
- Identification of a stable (few h tested) anode



Required Future Work

- Demonstrate compatibility of existing electrolytes with $CuFeS_2$ (concentrate Cu phase)
- Demonstrate Cu and Fe recovery/handling when both present
- Quantify anodic products recovery efficiency while producing Cu
- Mass, energy and electrical model of small and 100t/y reactors
- Study possible process to produce Cu wires

Transition

Next step is a pilot (at least 3Y – $6M): who will fund this and where will it operate?

- Existing mining companies with interest in on-site production
- Existing smelters with interest in incremental capacity increase or diversification
- $: large network of VC, individuals, venture arms, etc… very LME dependant

Approach existing parties that expressed interests with proof of concept (experimental results) and models/projection results for the larger scale pilot

- Demonstrate the ability to recovery Fe and Cu, with lower energy consumption, indicative of cost effectiveness of the concept
- Provide evidence of new opportunity for Te, Se or As
- Provide key dimensions and performances metrics of the 100t/y Cu reactors to engage players with the key opportunity for quick scale-up and technology transfer
- Evaluate additional cost benefits for unconventional ores (e.g. high As, high Fe, Mo recovery)

Implement a cost model coupled with the process model to enable quick evaluation of value for other products than Cu wires, or other metals than Cu

Questions?