FARADAY TECHNOLOGY, INC.

Electrodeposited Mn-Co Alloy Coatings for SOFC Interconnects

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Faraday Technology, Inc.

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Project ID: MN010

Overview

- **Timeline**
  - Start date: October 2010
  - End date: September 2012
  - Percent complete: ~23%
- **Budget**
  - DOE: $992,392
  - FY 2010: $497,629
  - FY 2011: $494,763
- **Barriers**
  - Increase SOFC system lifetime and efficiency
  - Lower SOFC system manufacturing costs
- **Partners**
  - West Virginia University

Relevance

- Program Objective – Develop, optimize & validate an inexpensive manufacturing process for coating metallic SOFC interconnects with Co and Mn.
  - Increase system lifetime and efficiency by:
    - Identifying the controlling mechanism for Cr diffusion
    - Producing a coating that reduces the Cr diffusion
    - Producing a coating that reduces oxide scale growth and delamination
  - Lower manufacturing cost
    - Demonstrate the flexibility to coat complex shapes and surface orientations
    - Maintain electrical conductivity
    - Minimize coating thickness while maintaining coating properties

Relevance

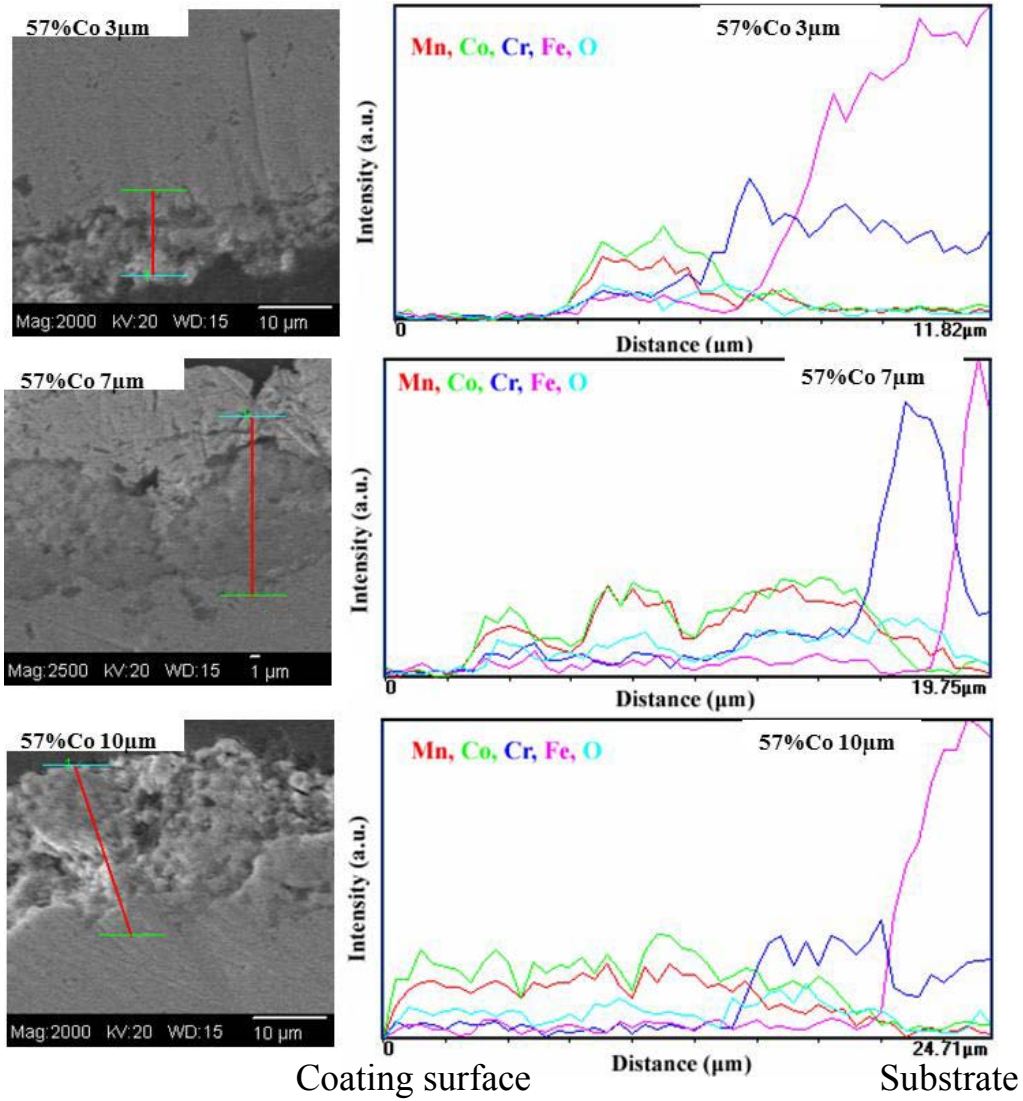
- FY 2010 Objectives
  - Design modification of electrodeposition cell
  - Long-term, high temperature thermal evaluation
  - Process development for 4”x4” planar interconnects

Approach

Electrodeposition of Mn-Co alloy onto metallic SOFC interconnects that is subsequently converted to a conductive spinel coating

Milestones			
Fiscal Year	***Title***	***Planned Completion***	***Percent Complete***
2011	1. Design/modification of 10” x 10” electrodeposition cell	May 2011	75%
2011	2. Long-term high temperature, thermal evaluation	September 2011	33%
2011	3. Process development for 4”x4” planar interconnects	September 2011	0%
2012	4. Process development for 4”x4” pattern interconnects	June 2012	0%
2012	5. Long-term on-cell performance evaluation	August 2012	0%
2012	6. Qualification/demonstration of IC in single cell test rig	September 2012	0%

Previous Accomplishments



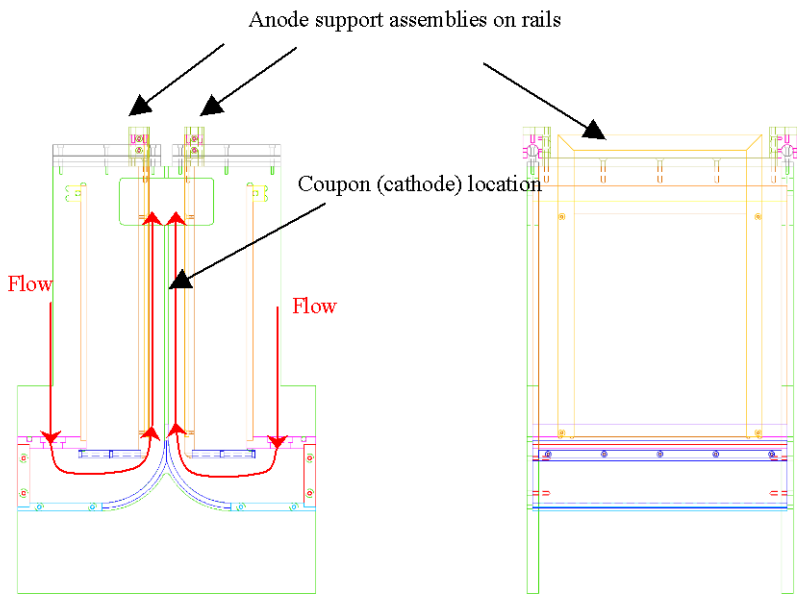
- Cross-sections of samples that underwent 500 hrs of thermal treatment at 800°C
  - Coating thickness was as deposited
  - Suggests a 3 um layer can produce Cr complexing and minimize Cr diffusion due to minimal porosity

ASR at 800°C

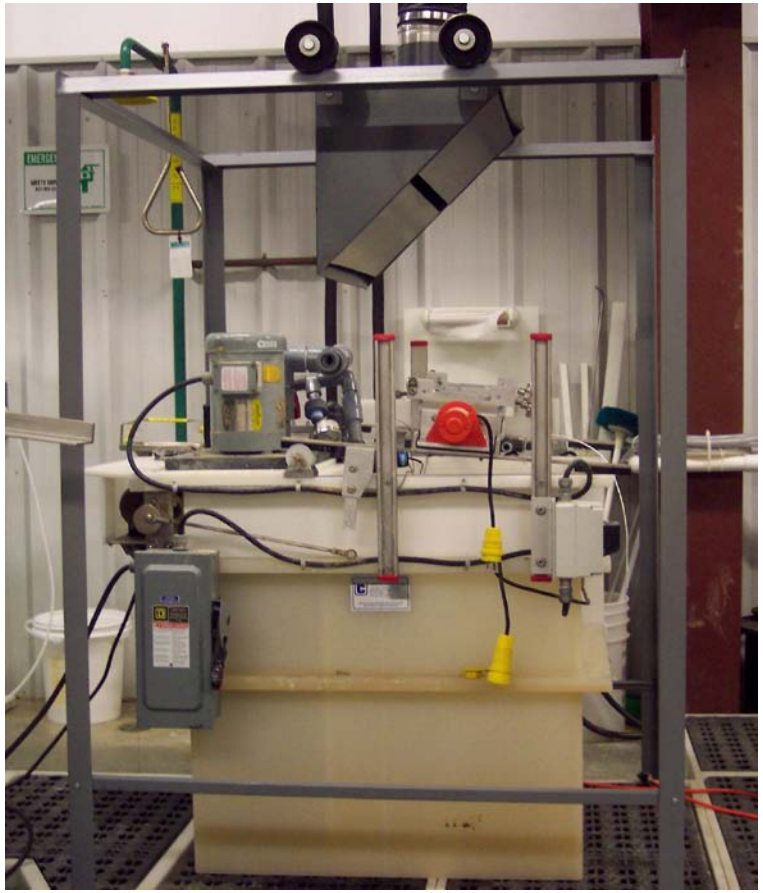
mΩ cm^2	100 hr	200 hr	500 hr
3 µm 40% Co	35	57	49
7 µm 40% Co	62	7	32
10 µm 40% Co	22	-	36
3 µm 85% Co	31	75	20
7 µm 85% Co	59	40	54
10 µm 85% Co	37	23	22
3 µm 57% Co	-	34	26
7 µm 57% Co	-	-	12
10 µm 57% Co	-	-	12

Progress To Date (3/11)

Design/modification to Electrodeposition Cell



In-progress design of double-sided flow module with anode support assemblies in place, shown in side cross-section (Left) and front cross-section (Right)



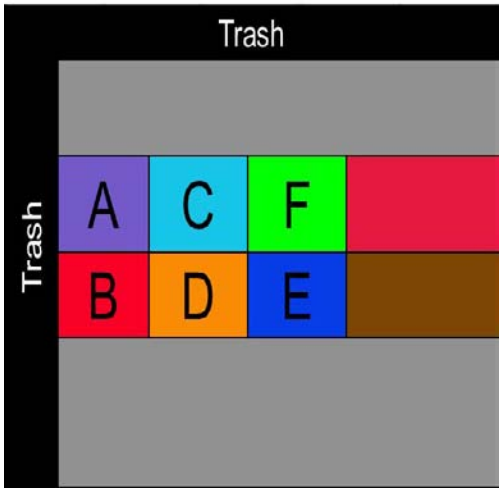
Electrodeposition Cell with newly installed exhaust system

Progress To Date (3/11)

Long-term High Temperature, Thermal Evaluation

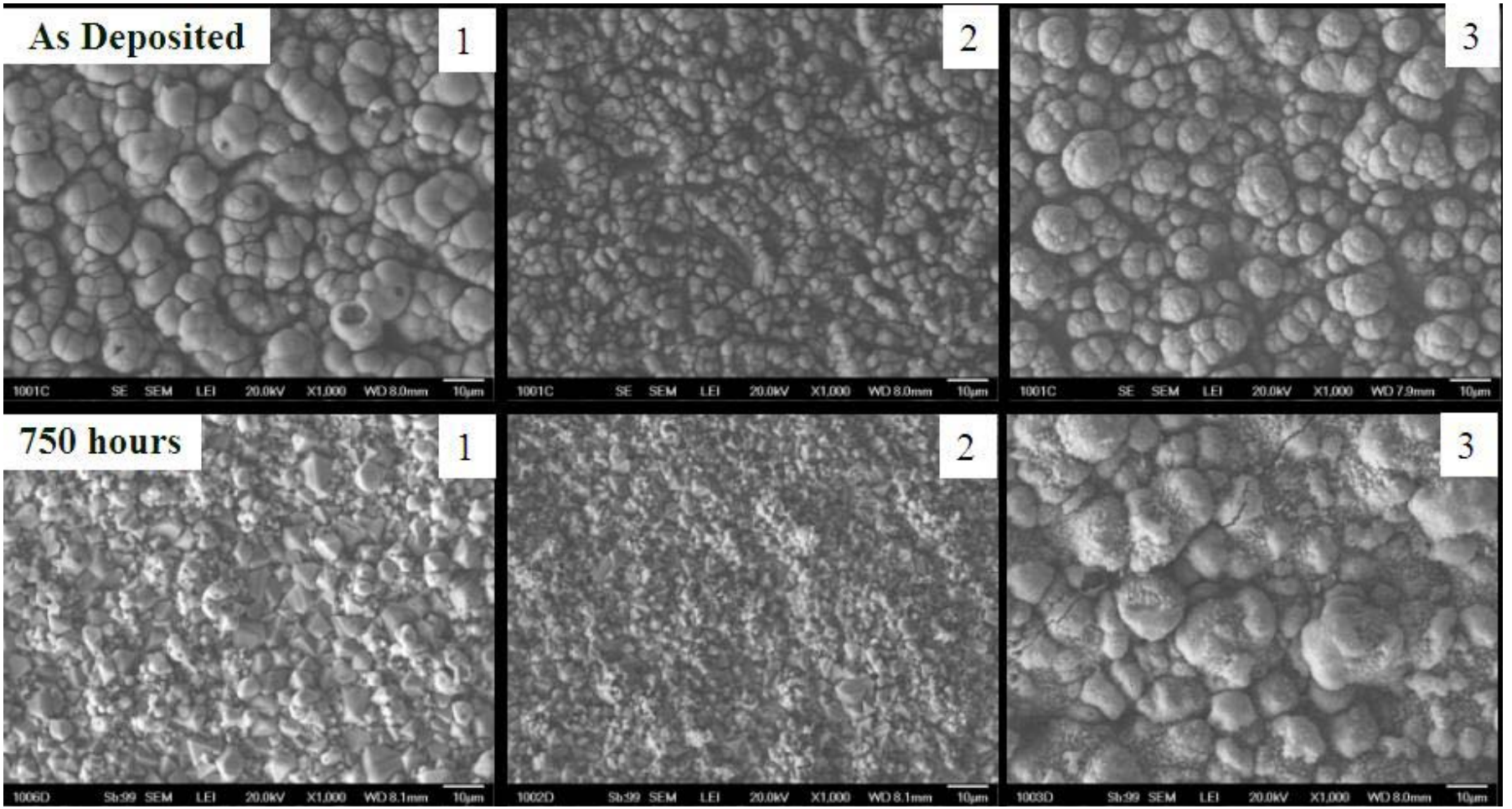
- Six samples were prepared using varying deposition parameters
  - 2 samples with higher Mn content and 4 with higher Co content
  - Target alloy thickness of 5 um
- Samples were sectioned to 10 mm x 10 mm and placed into a tube furnace at 850°C.
- Samples examined after 750, 1500, and 2000 hr

ASR Test order:C(t=0); D(t=750 hrs); E(t=1500 hrs); F(t=2000 hrs); and A(t=2000 hrs) (for Rockwell Test)



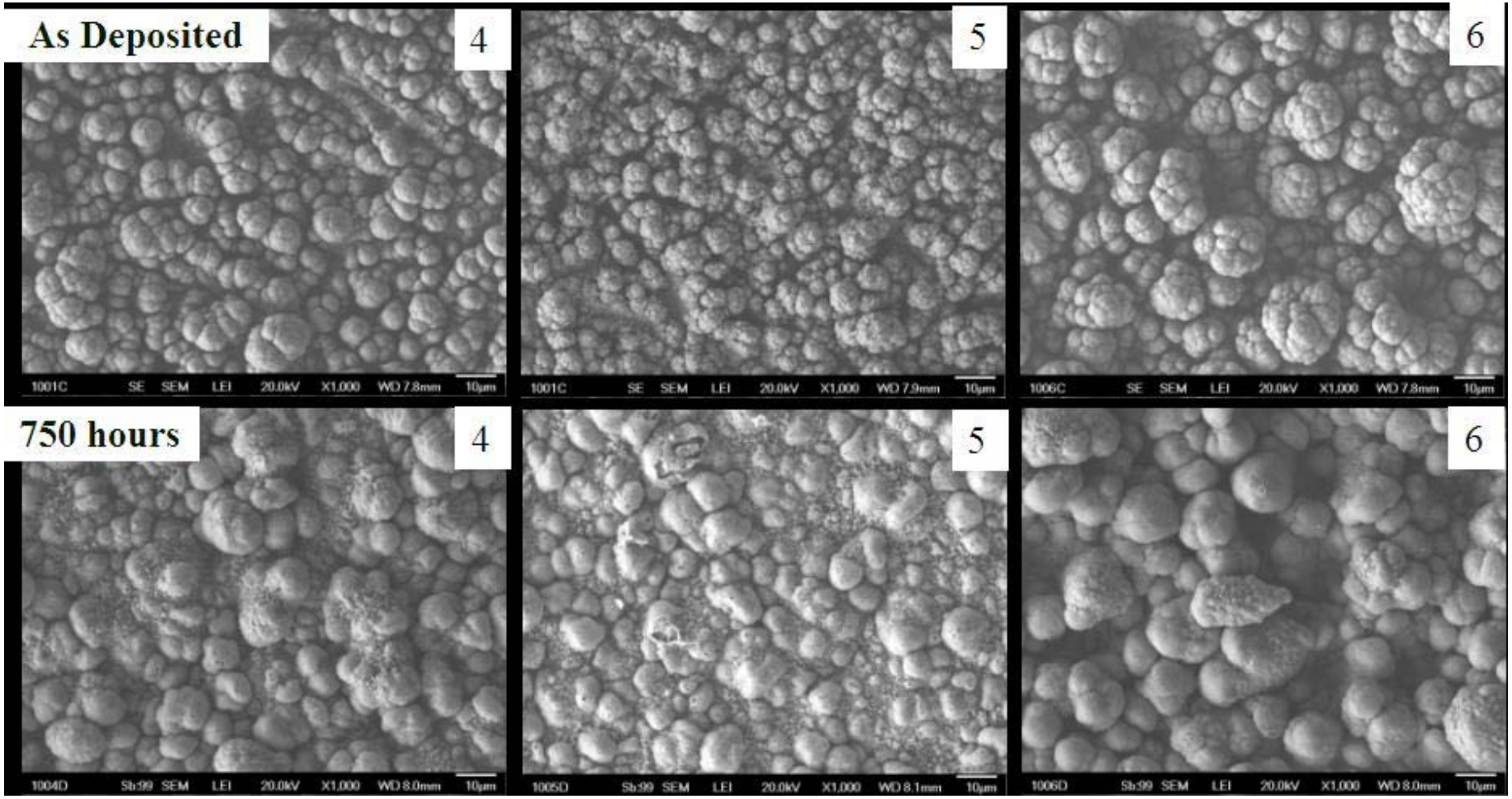
Progress To Date (3/11)

Extended Thermal Treatment Time Study



Progress To Date (3/11)

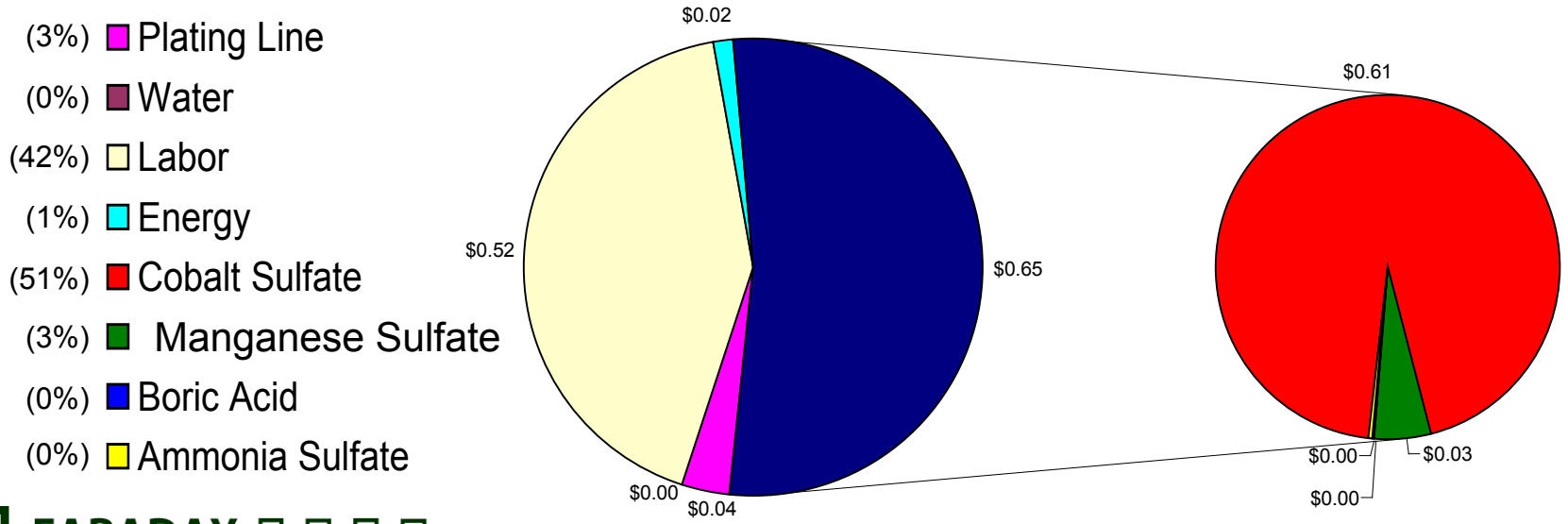
Extended Thermal Treatment Time Study



Progress To Date (3/11)

Economic Analysis

- Based on batch manufacturing, the DOE's high volume target of 1,600,000 plates per annum can be met at a cost of ~$1.23 per 25 x 25 cm interconnect
- Each as-deposited coating is 5 µm thick with a 65 wt% Co composition



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Collaborations

- Subcontractor
  - West Virginia University
    - WVU is assisting with the development and execution of the experimental plan, analysis of technical data and assessment of technical and economic feasibility of the program results.
    - Determination of the controlling mechanism for mitigation of Cr diffusion through in-situ high temperature XRD measurements and XPS depth profiling.
- Technology transfer
  - Client networking at technical conferences and industrial tradeshows, publish in technical trade magazines and journals, &memberships in industrial organizations that promote the fuel cell industry to engage industrial partners and identify a commercial penetration strategy
  - Faraday would expect to gain a small portion of the market share acquired by any technology transfer partner through intellectual property licensing by field of use or intellectual property acquisition in the form of patents for the process and enabling equipment, i.e. method and apparatus patents.

Future Work

- Continue analysis of extended thermal treatment samples
- Completion of modifications to electrochemical cell
- Determine plating parameters effect on chromium and oxygen diffusion
- Determine plate uniformity over large area flat T441 substrates
- Verify dual-sided plating flexibility
- Coat pattern interconnect
- Demonstrate coating uniformity and composition
- Testing in single cell and short stack SOFC systems

Summary

- Relevance: Develop, optimize & validate an inexpensive manufacturing process for coating metallic SOFC interconnects with Co and Mn to increase SOFC system lifetime and efficiency and lower manufacturing costs
- Approach: Electrodeposition of Mn-Co alloy onto metallic SOFC interconnects that is subsequently converted to a conductive spinel coating
- Progress: Modifications of electrodeposition equipment for coating full size SOFC interconnects, long term, high temperature thermal evaluation studies & continued development of economic assessment
- Collaborations: Subcontractor WVU to assist in process development and analysis and identification of industrial partners and commercial penetration strategy through client networking activities
- Future Work: Continued process development and analysis with final program goal of coating qualification test in single cell fuel cell test stand