Energy Materials Network
U.S. Department of Energy

HydroGEN
Advanced Water Splitting Materials

Advanced Coatings to Enhance the Durability of SOEC Stacks

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May 29th 2020

HydroGEN FY219 FOA Project Update

Project ID # P188

NREL | BERKELEY LAB | Sandia National Laboratories | INL Idaho National Laboratory | Lawrence Livermore National Laboratory | SRNL

Project Overview

Project Partners

Dr. Neil Kidner (PI), Nexceris LLC
Dr. Prabhakar Singh, University of Connecticut

Award #	**EE0008834**
Start/End Date	04/01/2020-03/31/2023
Total Project Value*	$1.25M (DOE + Cost Share)
Cost Share %	Cost Share: 20%

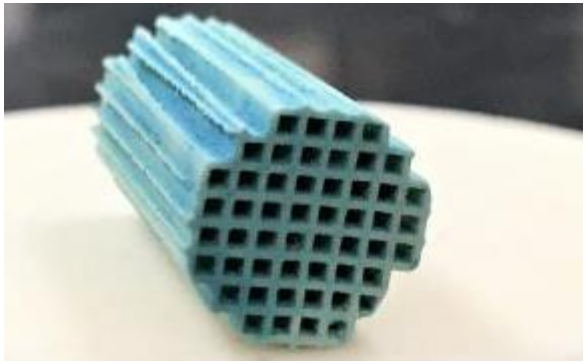
** this amount does not include cost share or support for HydroGEN resources leveraged by the project (which is provided separately by DOE)*

Project Vision

We are developing a comprehensive coating strategy to address the critical SOEC degradation mechanisms of metal corrosion and Cr evolution

Project Impact

Efficient and durable SOEC systems will support the transition to renewable, energy-efficient, and low cost H_2, creating paths to more valuable utilization of methane in chemicals and fuels rather than heat.



Approach- Summary

Project Motivation

- Nexceris has over 20 years' experience building and testing SOFC stacks.
- Successfully commercialized protective and catalyst coatings for the SOFC market
- Leverage this expertise to advance SOEC technology readiness.
- Develop an integrated two-coating strategy to enhance SOEC stability.

Barriers

1. Deconvolution of degradation mechanisms – *Careful EIS analysis of cell performance.*
2. Demonstration of coating technology at production relevant scale – *Use Nexceris' existing stack platform*

Key Impact

Metric	State of the Art	Expected Advance
Degradation Rate	*> 10 mV/kh*	*< 4 mV/kh*
Technology Adoption cost	*> $10/kW*	*< $3/kW*
Current Density *@ 1.4 V/cell*	*> 0.5 A/cm²*	*> 1.0 A/cm²*

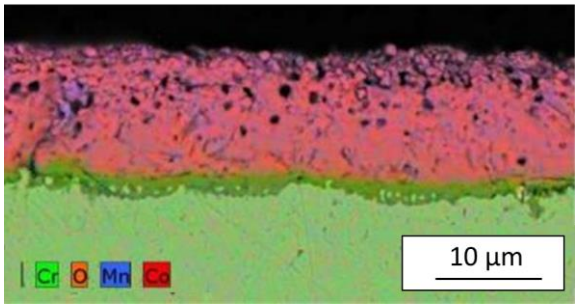
Partnerships

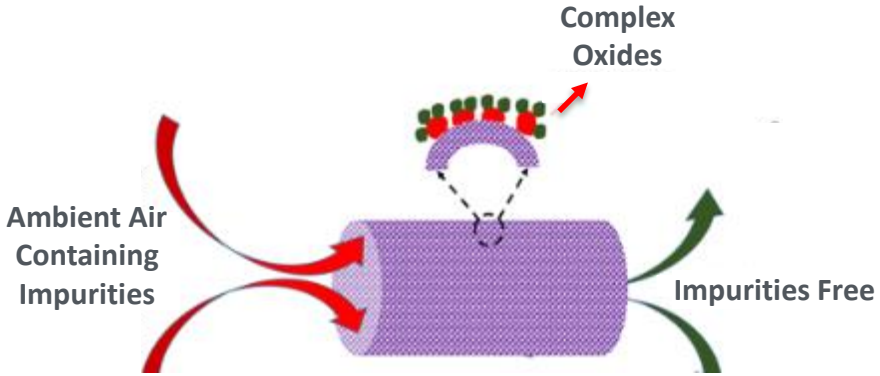
- Dr. Singh brings an in-depth industrial and basic research background in the field of SOFC and electrolysis. His research group at UCONN have developed a range of Cr-getter materials
- HydroGEN node partners at INL and LBNL provide extensive experience with SOFC/SOEC fabrication and testing

Approach- Innovation

Innovation: Integrated Coating Strategy to Reduce SOEC degradation

1. Re-engineered IC coatings and Cr-getters tailored for SOEC
2. Novel two-component BoP coating





<u>Budget Period 1</u>: Identify a protective IC coating for SOEC operation

- Gap analysis of *ChromLok* IC-coating (SOFC vs. SOEC)
- Down-selection of optimized coating formulations
- Baseline single-cell test capability that can achieve DOE target
- **Go/No-Go Decision:** Demonstrate the efficacy of the down-select IC coating

  ASR of < 50 mΩ-cm^2 through electrochemical ASR testing under anode SOEC operating conditions (30% oxygen in air with 3% H_2O) for 500 hours at a current density of 1 A/cm^2.

Relevance & Impact

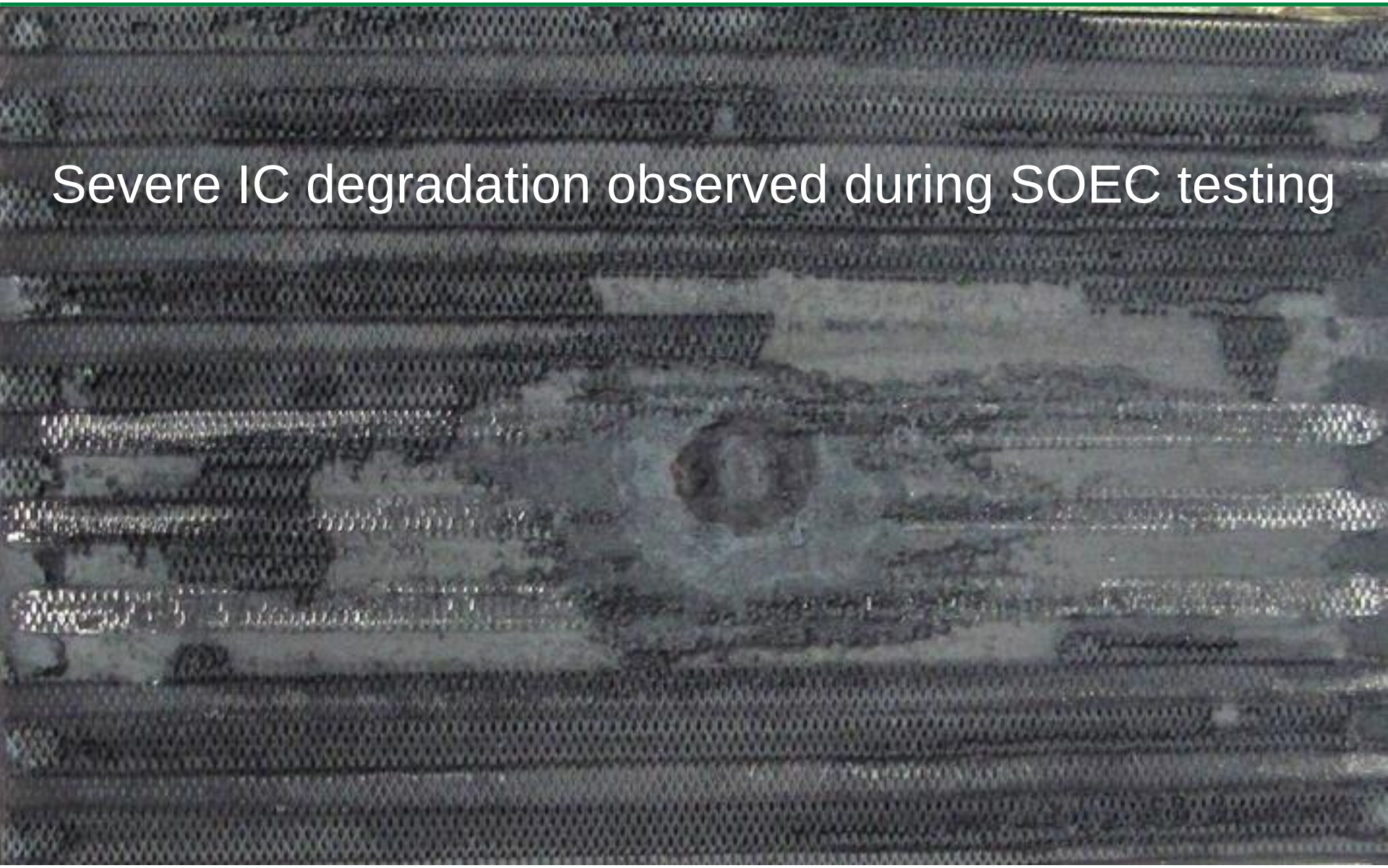
- H2@Scale concept envisions sustainable, large-scale H_2 production from excess grid power generation
- SOECs are **not as commercially advanced** as alkaline & PEM electrolysis, **adoption limited by degradation**
- This project will develop a new integrated coating strategies to address degradation caused by metal corrosion/chromium evolution from metallic components, to **improve SOEC durability and accelerate commercialization**
- Focus on low cost, scalable technology that can be implemented
- **Nexceris is committed to collaboration** and working with partners to transform powerful ideas into product solutions
- This project allows Nexceris to strengthen relationships with partners within the HydroGen Consortium

Effective Leveraging of the EMN Resource Nodes

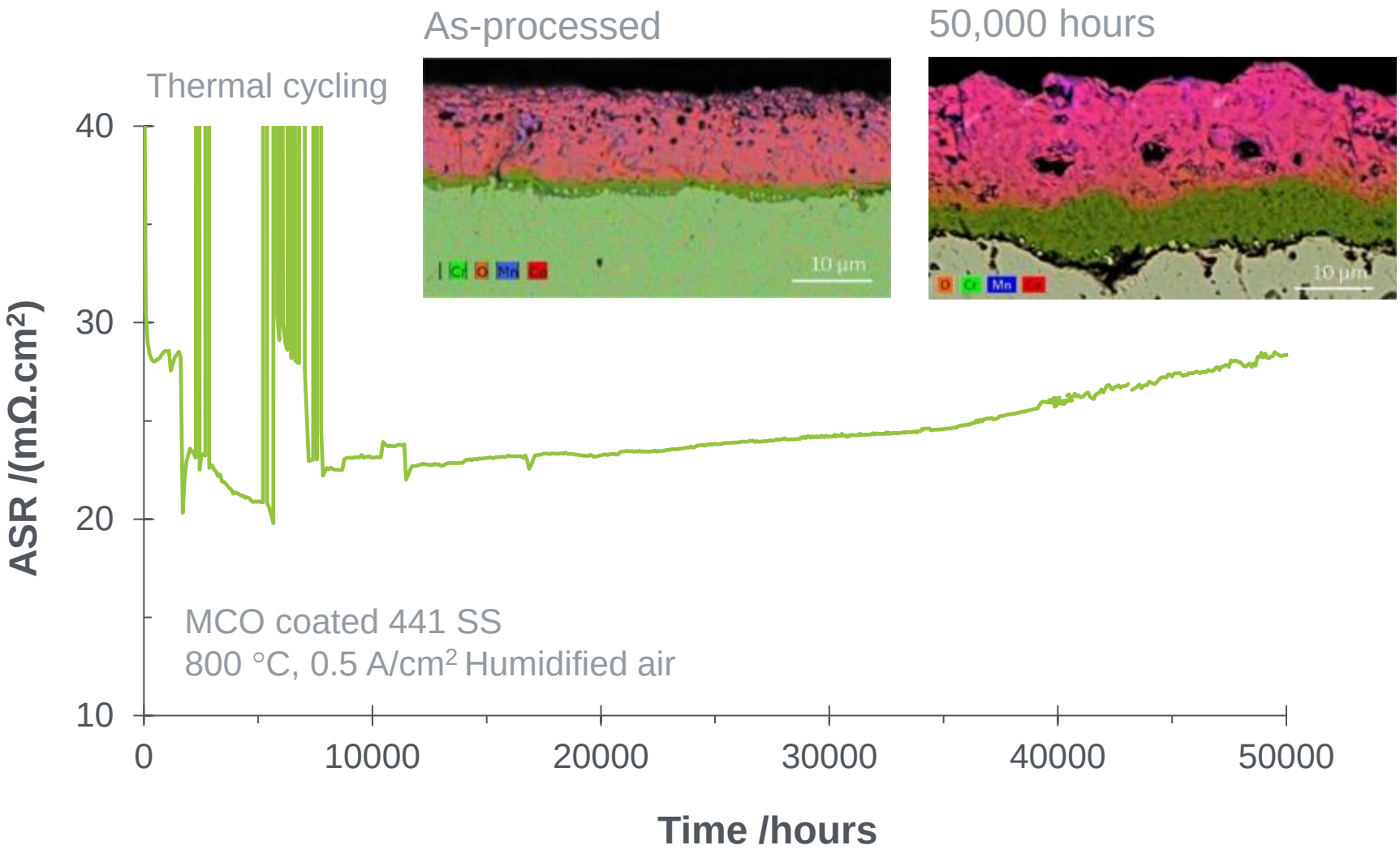
In Budget Period 1 the project team will collaborate with:

1. Advanced Electrode and Solid Electrolyte Materials for Elevated Temperature Water Electrolysis *(INL: D. Ding)*
    - ASR testing with post-mortem analysis
2. Analyses and Characterization of Material Performance in Hydrogen and other Environments (*INL: G. Ilevbare and M. Glazoff*)
    - Coatings and cross-scale model for degradation
3. Metal-Supported SOEC Cell (*LBNL: M. Tucker*)
    - Exposure testing of coated and uncoated samples under SOEC application conditions (including dual-atmosphere) to understand oxidation behavior

Project Motivation



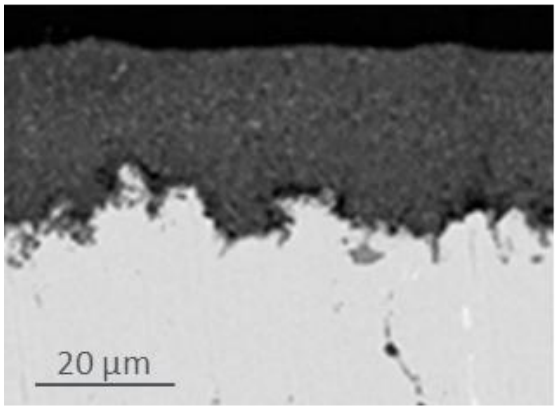
ChromLok™ SOFC Protective Coating



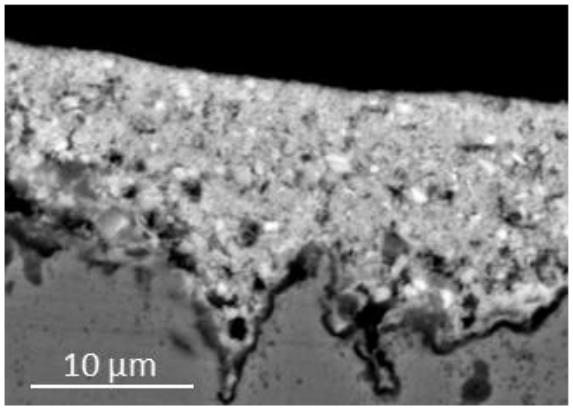
Overlay Coatings

- Surface pre-treatment promotes coating adherence
- Enables coatings that otherwise wouldn't be possible on metal components

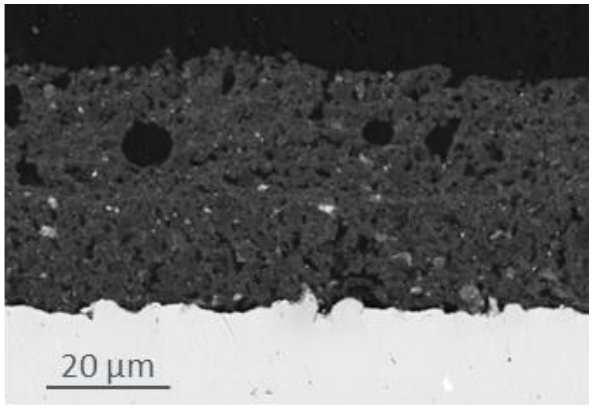
Electrical Isolation Coating



Seal Coating



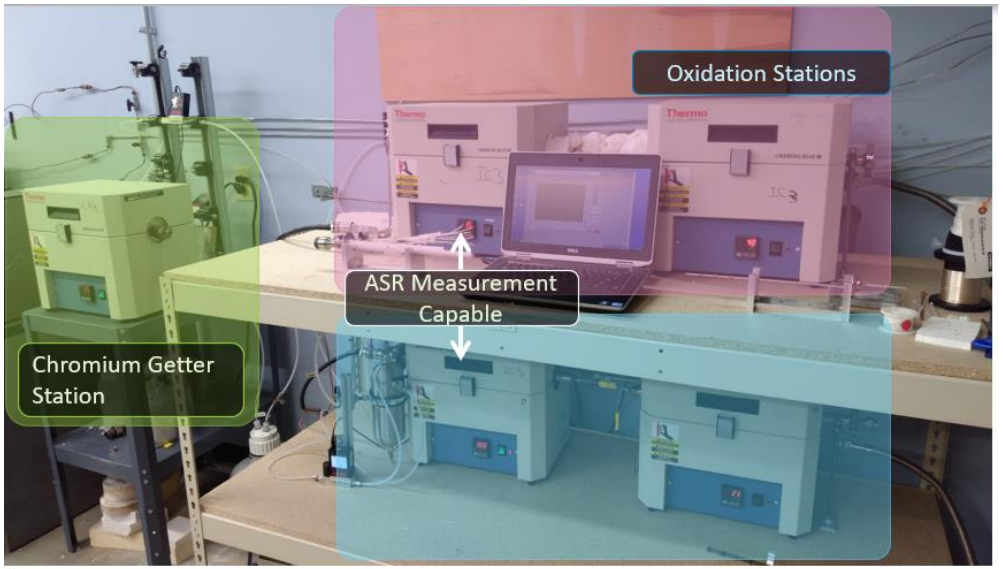
Catalyst Coating



- Use approach to develop new coating strategies for SOEC systems

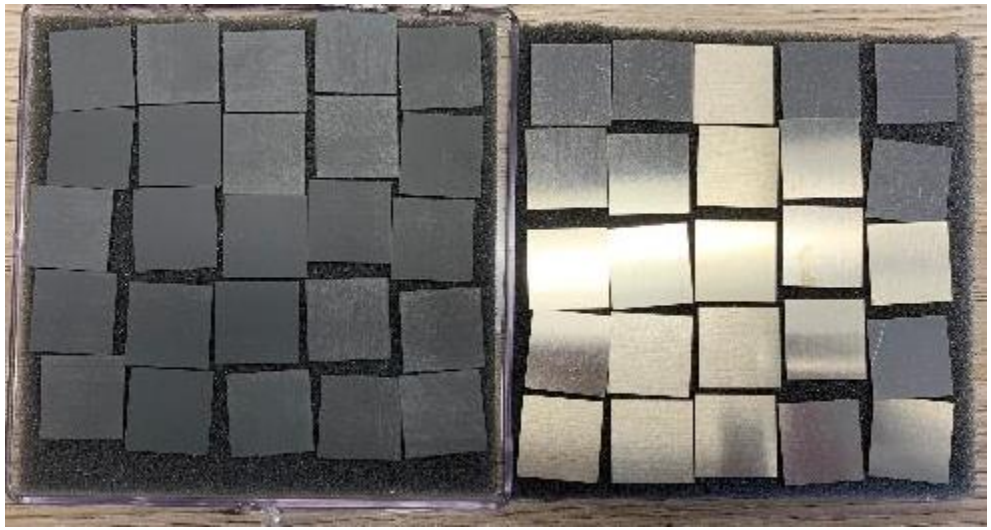
Accomplishments and Progress

- Oxidation and ASR testing stands have been assembled at Nexceris (7 stands)
- Chromium getter station was assembled
- The current setup will enable oxidation and ASR measurements in three different environments/conditions simultaneously on multiple samples at a time
- Chromium getter stands will allow for evaluation of the getter materials
- Temperature calibration was conducted on all furnaces; calibration was conducted on all measurement equipment

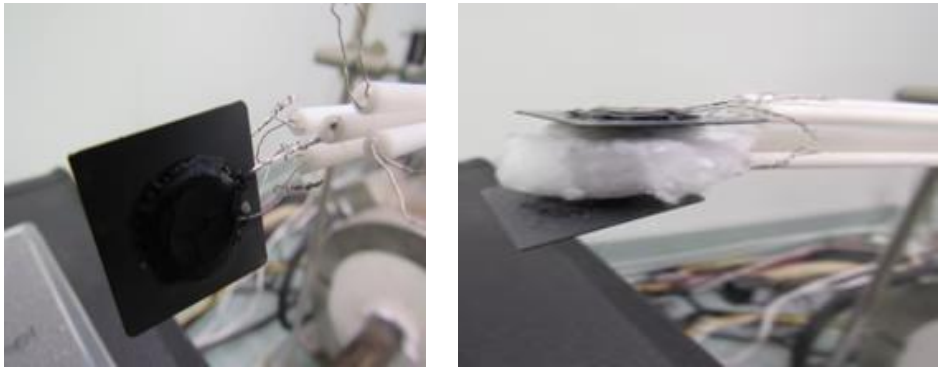


Accomplishments and Progress

- Bare and MCO coated coupons were prepared and are currently being tested under different conditions
- Long-term ASR and oxidation data is being collected continuously with target of at least 500 hours of testing
- Oxidation tests incorporate intermittent weight gain measurements
- Coated and uncoated coupons were shipped to Nodes and University of Connecticut
- Nexceris team is further optimizing the current coatings



2 x 2 cm coated coupons (left) and uncoated (right)



Coupons prepared for 4-probe ASR testing

Summary Slide

- The oxidation and ASR test stands were assembled at Nexceris enabling three different environments/conditions to be tested long-term simultaneously
- Chromium getter stand was assembled at Nexceris for long-term getter testing
- Coated and uncoated coupons were prepared and shipped to collaborators for testing (once the national labs and universities are opened for business)
- Oxidation and ASR tests are currently undergoing at Nexceris