



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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HydroGEN FY219 FOA Project Update

Project ID # P188



Project Overview

Project Partners

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

Project Vision

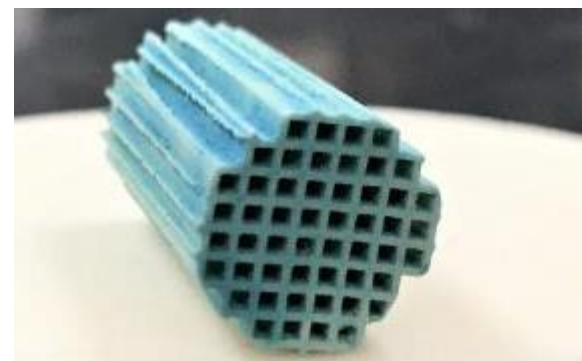
We are developing a comprehensive coating strategy to address the critical SOEC degradation mechanisms of metal corrosion and Cr evolution

Project Impact

Efficient and durable SOEC systems will support the transition to renewable, energy-efficient, and low cost H₂, creating paths to more valuable utilization of methane in chemicals and fuels rather than heat.

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)*





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/cm ²	> 1.0 A/cm ²

Partnerships

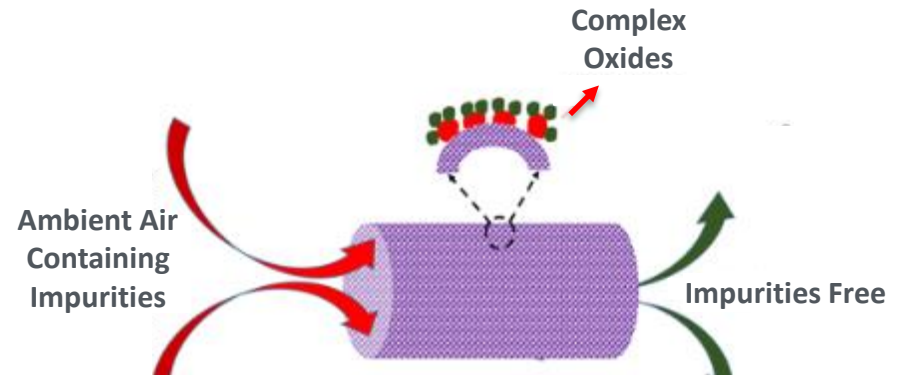
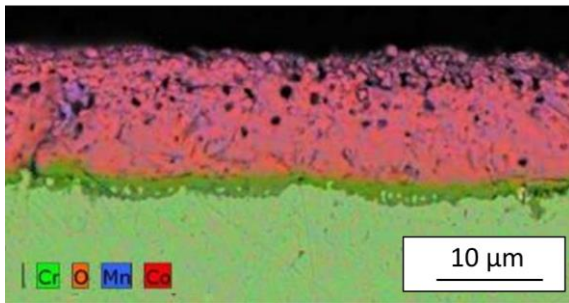
- Dr. Singh brings an in-depth industrial and basic research background in the field of SOFC and electrolysis. His research group at UCONN have developed a range of Cr-getter materials
- HydroGEN node partners at INL and LBNL provide extensive experience with SOFC/SOEC fabrication and testing



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



Budget Period 1: 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 $< 50 \text{ m}\Omega\text{-cm}^2$ 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 H₂ 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

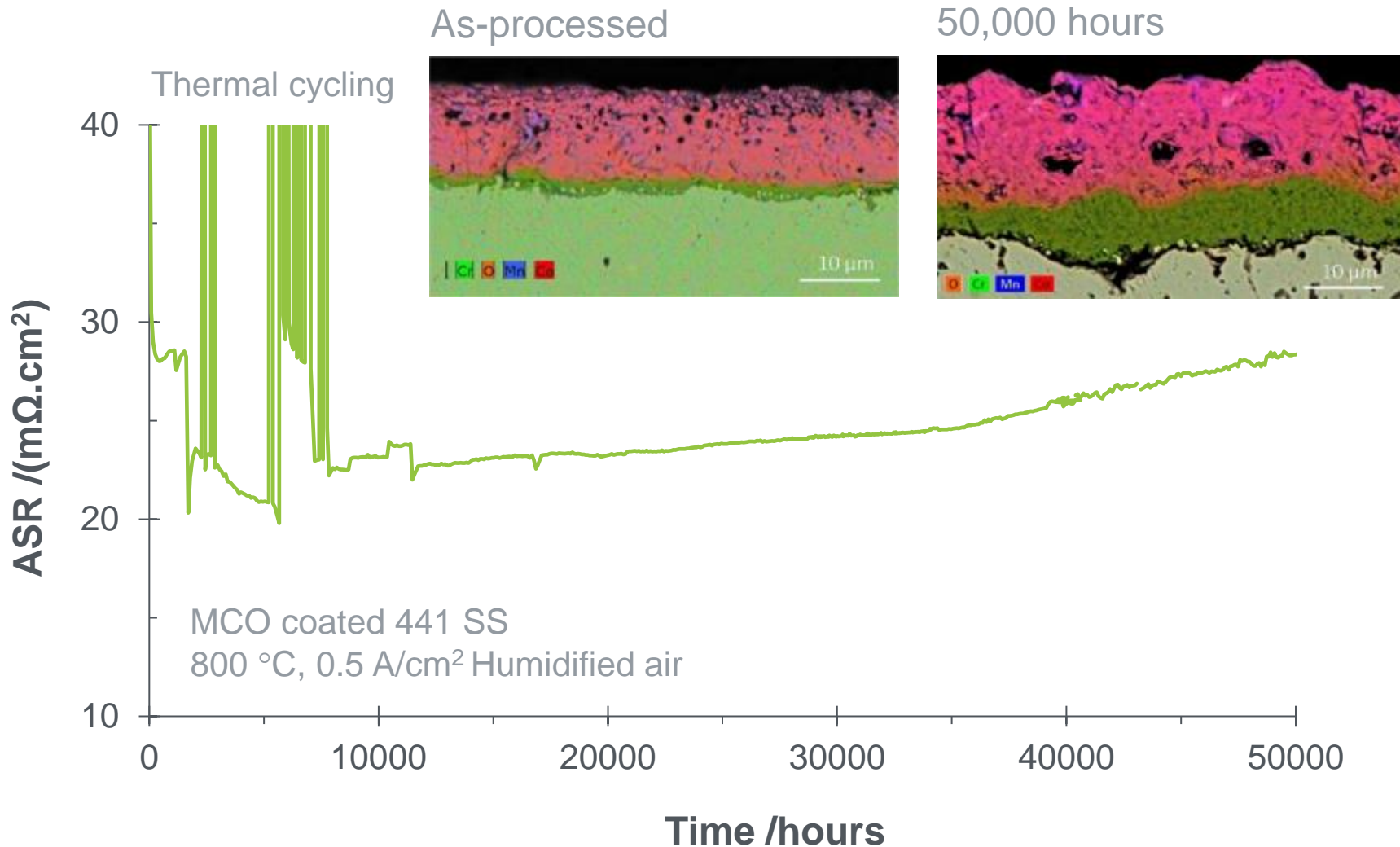


Project Motivation

Severe IC degradation observed during SOEC testing



ChromLok™ SOFC Protective Coating

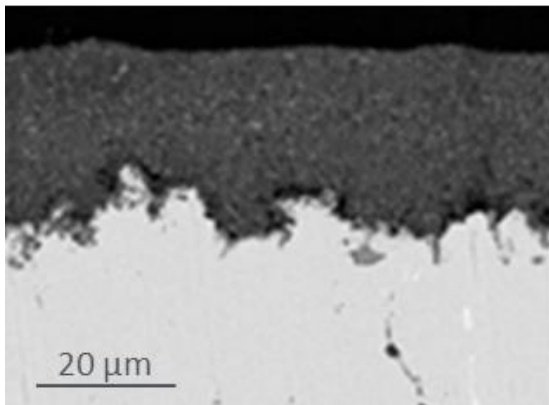




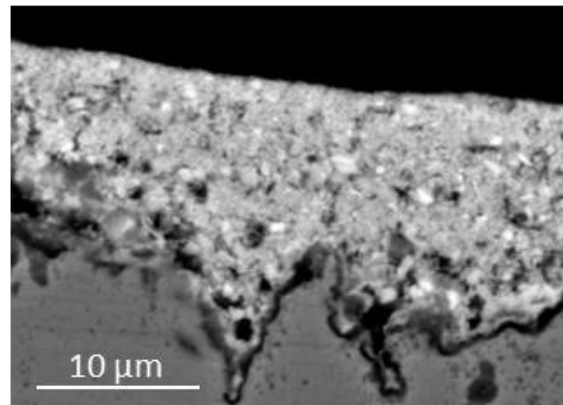
Overlay Coatings

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

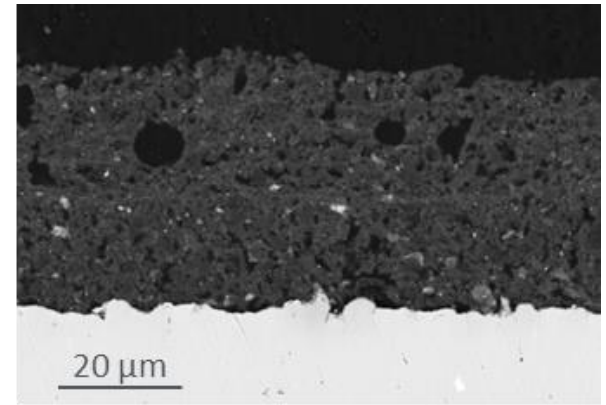
Electrical Isolation Coating



Seal Coating



Catalyst Coating

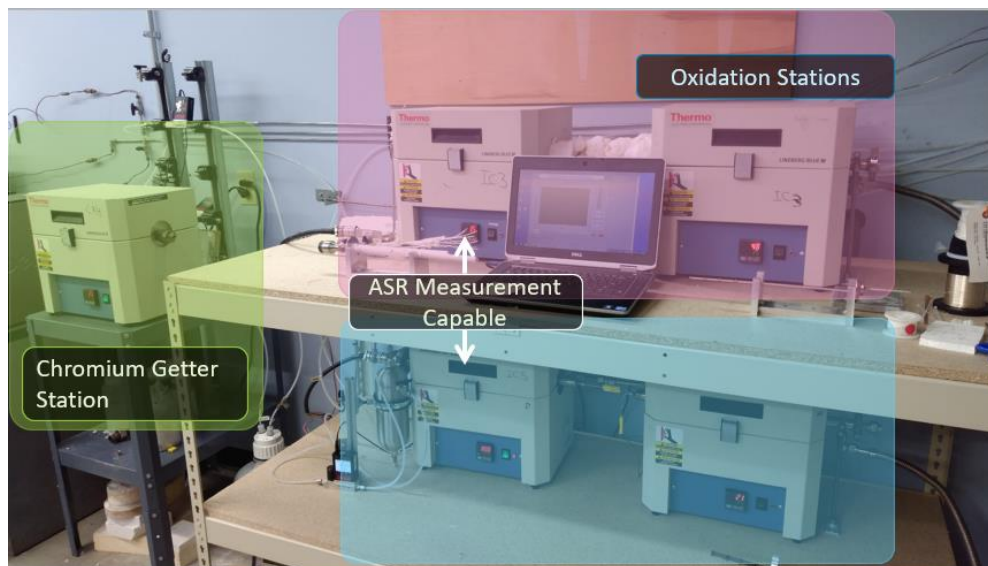


- Use approach to develop new coating strategies for SOEC systems



Accomplishments and Progress

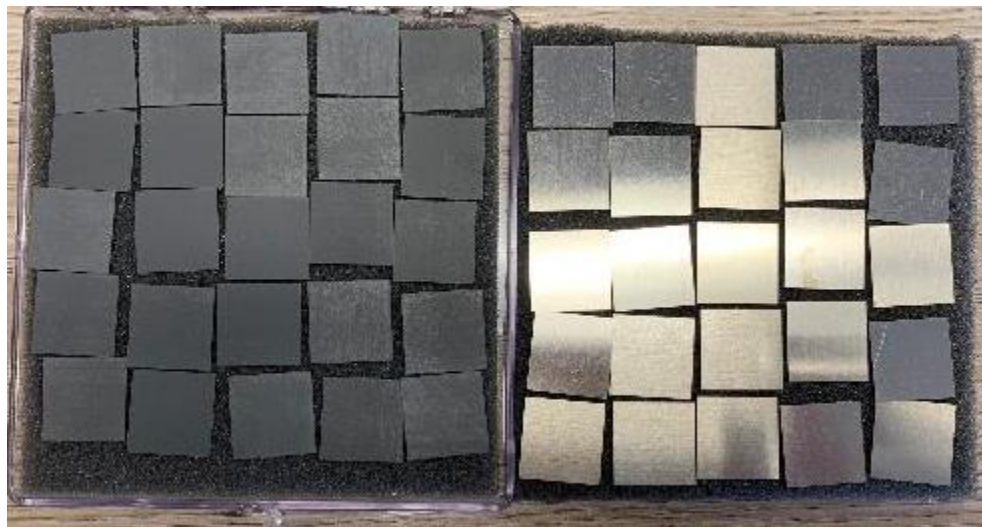
- Oxidation and ASR testing stands have been assembled at Nexceris (7 stands)
- Chromium getter station was assembled
- The current setup will enable oxidation and ASR measurements in three different environments/conditions simultaneously on multiple samples at a time
- Chromium getter stands will allow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



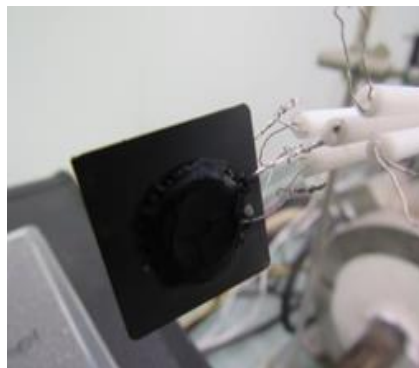


Accomplishments and Progress

- 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

