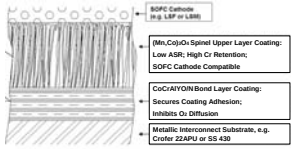
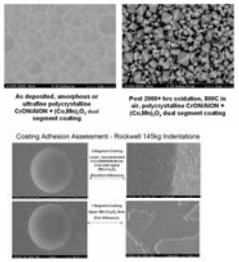
Montana State University

High Temperature Electrochemistry Center Research

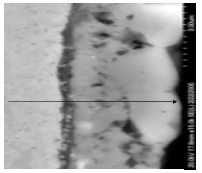
Hybrid Coating Architecture and Composition



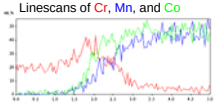
Surface Morphology Results



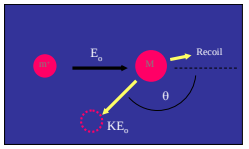
Cross Section SEM/EDS Results:



Linescans of Cr, Mn, and Co

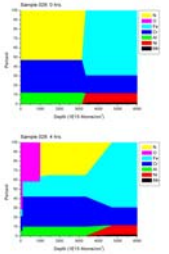


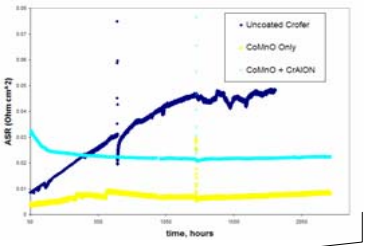
Ion Beam Analysis: RBS, NRA



- Kinematics: mass resolution
- Energy loss: depth scale
- RBS has more sensitivity for heavy elements
- Nuclear reaction: use (d,p) reactions for light elements (O, N, C) and (p,α) for ^{18}O trace analysis

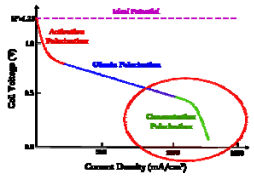
RBS Concentration Profiles: Before(top) after (bottom) 4 hrs @ 800 C

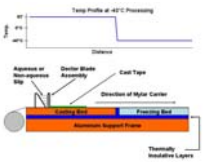




Microstructurally Engineered Electrodes

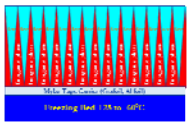
Poor microstructures can limit high current density performance/fuel utilization

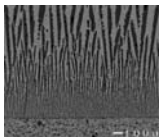


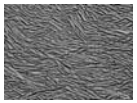


Freeze - Tape Casting

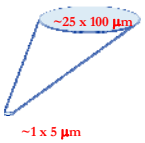
Freeze Processed Microstructures

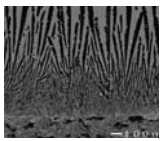






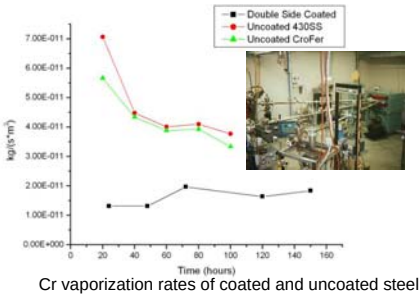
Freeze Cast Surface





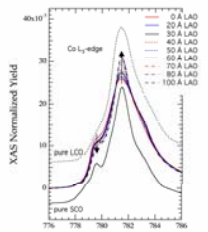
Past Year Objectives

- Develop thin corrosion resistant coatings on steel interconnect plates that are: (1) good electron conductors, (2) thermally stable, (3) good barriers to outward diffusion of Fe and Cr from the interconnect plate, and (4) good barriers to inward oxygen diffusion and growth of oxide scale.
- Characterize SOFC interconnect material systems' behavior under relevant exposures to develop understanding of essential interfacial chemistry and transport mechanisms.
- Investigate Cr poisoning processes in SOFCs through quantitative measurements of (1) Cr volatility rates from coated/uncoated steel surfaces, and (2) oxygen diffusion and surface exchange rates for electrolyte and cathode materials with surface impurities.
- Investigate the possibility of engineering pore structures and determine their impact on SOFC performance.
- Determine the effects of interfacial strain from lattice mismatch at interfaces of technologically relevant SOFC materials using X-ray techniques.
- Investigate potential for brazed seals for SOFCs
- Create an X-ray compatible electrochemical cell to study the SOFC structural and electronic properties under operational conditions.
- Fabricate and characterize proton conducting ceramics for use in hydrogen separation membranes and hydrogen sensors.
- Measure and analyze anode gas flow and tortuosity for various anode structures.
- Develop a physically-based dynamic model for a solid oxide fuel cell (SOFC) stack.
- Develop a fuel cell model reference simulator
- Demonstrate modular power electronics that can be used with transient recognition control (TRC) and develop and demonstrate TRC for fuel cell systems in an FPGA system



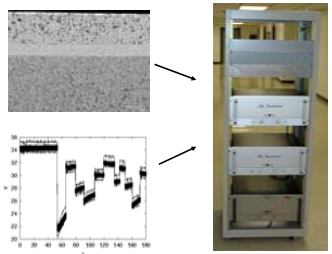
Cr vaporization rates of coated and uncoated steels as a function of time at 800 ºC in humid air.

MSU Materials X-ray Characterization Facility at the National Synchrotron Light Source



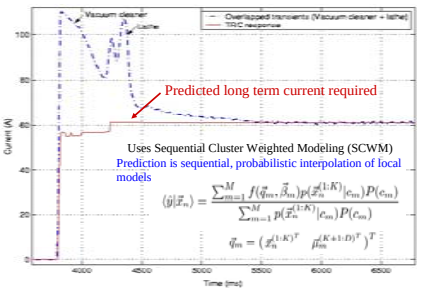
Co L2,3 edge XAS spectra for LSCO thin films capped with LAO shown as a function of overlayer thickness (increased induced stress in the LSCO films). Also shown are spectra for pure SCO and pure LCO.

Full-stack simulator
Accelerated test platform for full-scale electronics & controls



50V, 75A
3500 W
4-quadrant
> 100 kHz

Virtex-II FPGA TRC Implementation
(real-time implementation of TRC in FPGA)

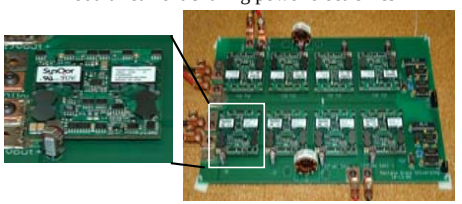


Uses Sequential Cluster Weighted Modeling (SCWM)
Prediction is sequential, probabilistic interpolation of local models

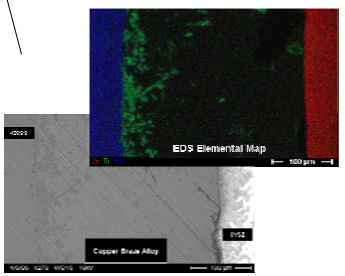
$$\hat{y}(\vec{x}_n) = \frac{\sum_{m=1}^{M} f(\vec{q}_m, \vec{\beta}_m) p(\vec{x}_n^{(1:K)} | c_m) P(c_m)}{\sum_{m=1}^{M} p(\vec{x}_n^{(1:K)} | c_m) P(c_m)}$$

$$\vec{q}_m = \left(\vec{x}_0^{(1:K)T} \quad \vec{y}_0^{(K+1:D)T} \right)^T$$

Modular current-sharing power electronics



Current sharing control integrates with TRC.



- MSU synthesized, non-precious metal copper based braze
- inert atmospheric brazed
- hermetic seal provided by braze/ceramic chemical bond