Cathode/Electrolyte Interface Material Studies

A. Lussier, M. Finsterbusch, E. Negusse, Y.U. Idzerda

Department of Physics
Montana State University
Bozeman, MT 59717

Abstract: Our goal is to identify and understand SOFC cathode material issues and potential degradation mechanisms. We utilize synchrotron based techniques to probe materials with elements specificity with a particular interest in interfaces.

Acknowledgements: This work is supported by DOE grant DE-8NT0004115. The National Synchrotron Light Source is supported by DOE.

Experimental Details

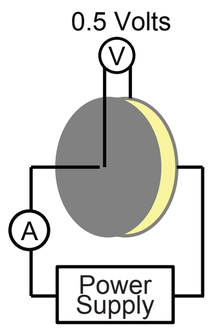
Sample Preparation

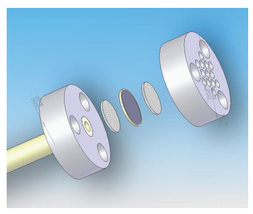
Half-cell samples (electrolyte and cathode) are prepared to focus our attention on the electrolyte, cathode, and their interface. Counter-electrodes are necessary for testing purposes and are fabricated identically to the cathode, resulting in symmetrical test cells.

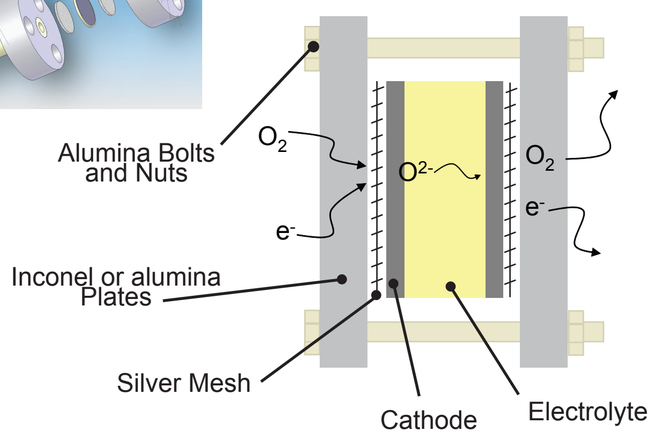
The electrolytes are prepared by uniaxially pressing and sintering $Gd_{0.10}Ce_{0.9}O_2$ powder (35.3 m^2 /g) from Fuel Cell Materials. Cathode inks are prepared from $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_2$ (5.4 m^2/g) powder also from Fuel Cell materials. This technique allows for quick and simple sample preparation. Future experiments will be conducted on Pulsed Laser Deposited (PLD) samples for more careful characterization of cathode/electrolyte interfaces by synchrotron based techniques.

Sample Testing

Samples are sandwiched between plates with silver (or gold) mesh contacts. Inconel plates can be used to provide built-in Cr contamination. Alumina plates provide a clean environment to test other operating parameters such as oxygen partial pressure or moisture content.

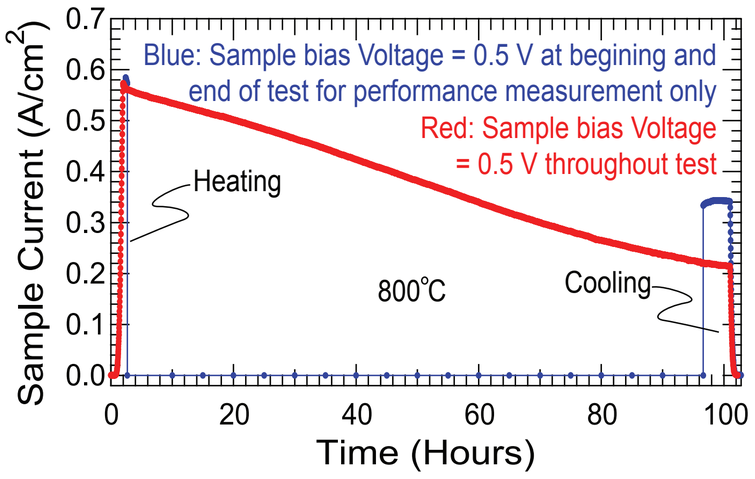






Recent Experimental Results

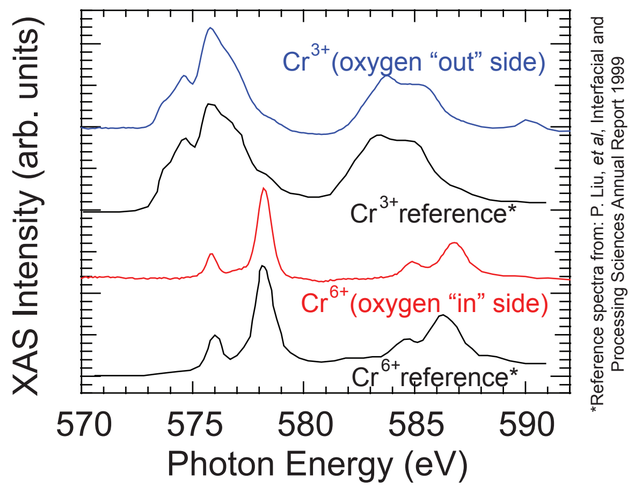
Various Degradation Mechanisms



The sample under a constant bias voltage of 0.5V degraded by ~ 60% over 100 hours. The sample which sat idle for most of the test only suffered a ~ 40% decline in current..

This result confirms that part of the degradation is driven by the high temperature, and another is driven by the current density. Another experiment presented here shows how chromium deposition is affected by current density.

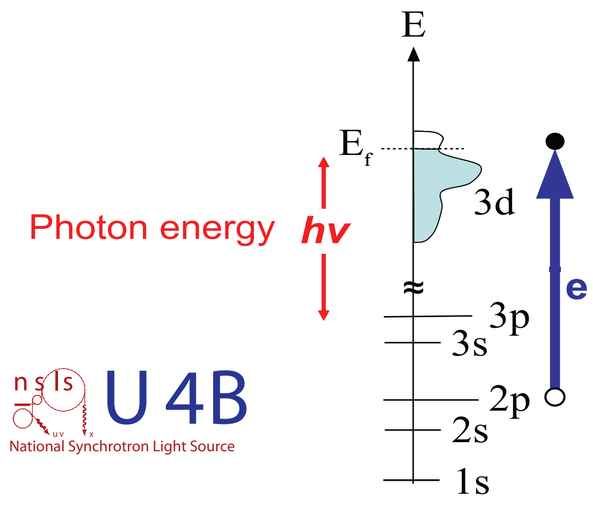
Effect of Voltage Bias Direction on Chromium Deposition



The X-ray Absorption Spectroscopy (XAS) allows us to unambiguously identify elemental oxidation states. The spectra above show that chromium was deposited on both sides of the half-cell. Furthermore, the cathode side oxidation state is 3+, while it is 6+ on the counter-electrode side. The symmetrical nature of the half-cell confirms that this effect is due to current direction only.

Experimental Techniques

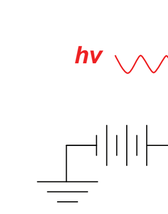
Element Specific Spectroscopy

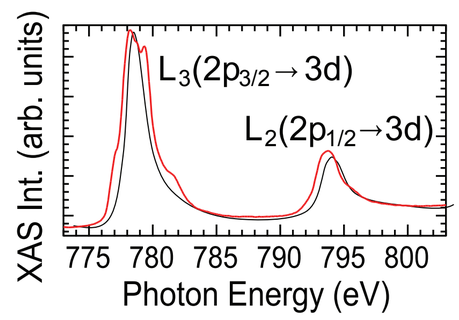


National Synchrotron Light Source U 4B

Using synchrotron radiation allows us to tune the photon energy to match the absorption edge of specific elements. This allows us to probe the chemical and structural state of the element of our choice in a sample, including elements in burried layers of a multilayer sample. The probing depth can also be varied using various detection techniques such as total electron yield or fluorescence.

X-ray Absorption Spectroscopy



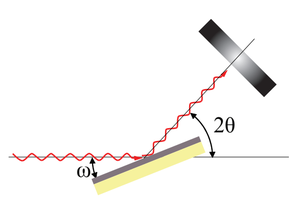


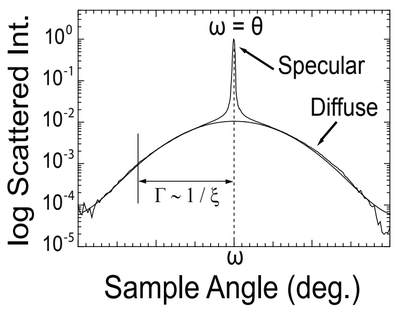
— Cobalt metal

— Cobalt in CoO

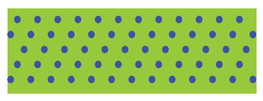
X-Ray Absorption Spectroscopy provides element specific chemical and structural sample information, as illustrated for cobalt in the spectra above.

X-ray Resonant Scattering

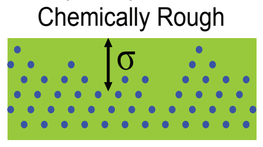




Physically & Chemically Smooth

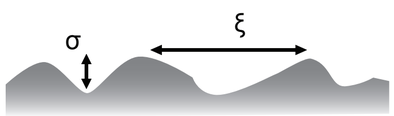


Physically Smooth Chemically Rough



Specular vs Diffuse Intensity → Perpendicular Roughness (σ)

Width of Diffuse Background → In-plane Correlation Length (ξ)



Scattering experiments allow us to acheive surface and interface roughness information. Because the technique is element specific, we can use it to identify elemental migration accross interfaces.

Conclusions

Degradation occurs at an accelerated rate in our half cells which are exposed to a constant current density compared to those exposed only to high temperatures. However, even cells exposed only to high temperatures show degradation. We therefore must conclude that both current and temperature related degredation occurs, perhaps in addition to other processes.

Chromium deposition at the cathode side (where oxygen enters the electrolyte) of our symmetric half cells results in Cr6+ while deposition on the counter electrode side results in Cr3+, confirming the existence of a current density effect on Cr deposition.