

MATERIALS

SOFC ANODE MATERIALS

OVERVIEW

Most common SOFC anode materials are Ni-YSZ composites

- Excellent catalytic activity
- Good electronic conductivity

Ni metal is readily oxidized to NiO or Ni(OH)_x in electrolysis environment

- severe electrode polarization and deactivation
- coarsening with extended time at temperature

To address this, we are synthesizing materials and manufacturing a Ni-free composite anode, primarily an all oxide Mixed-Ionic-Electronic Conductor (MIEC)

The MIEC is yttrium-doped strontium titanate SrTiO₃ (Sr_{1-1.5x}Y_xTiO_{3-δ})

Strontium, magnesium and cobalt doped lanthanum gallate (LSGM: La_{1-x}Sr_xGa_{1-y-z}Mg_yCo_zO_{3-δ}) is used in the composite anode

Lanthanum-doped Ceria (LDC) (Ce_{1-x}La_xO_{2-δ}) is also used in the composite anode

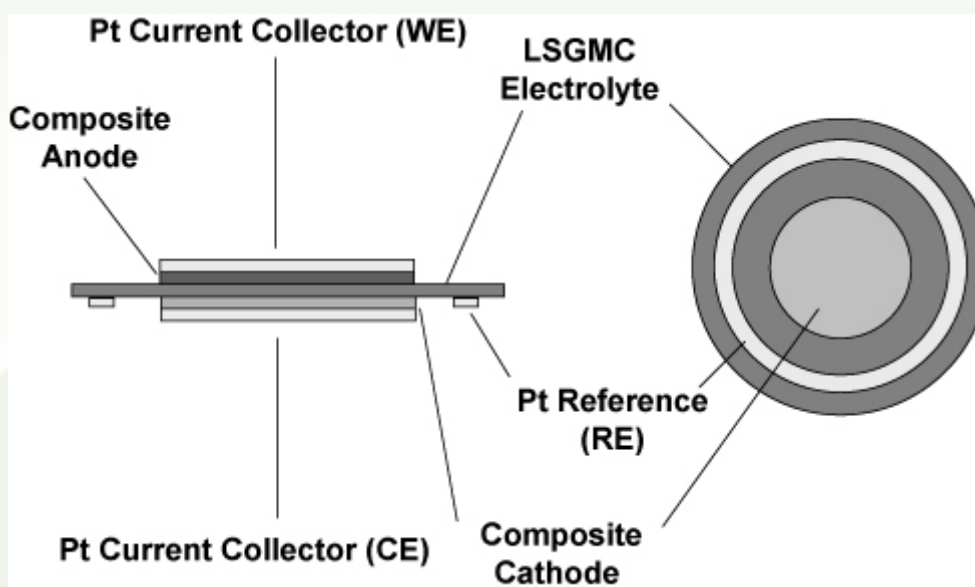
Sr_{0.86}Y_{0.08}TiO_{3-δ} has relatively high electrical conductivity and good chemical stability under reducing conditions [1,2]

GOAL AND OBJECTIVES

- Investigate nickel-free anode materials for the anode of a reversible SOFC
- Develop a novel sol-gel process for synthesis of SYT
- Use the novel sol-gel process to synthesize SYT
- Measure SYT properties to determine whether the materials are promising for use in reversible SOFC anodes
- Manufacture composite SYT anodes (with LDC, LSGMC) and test them in full SOFC button cells

Solid Oxide Fuel Cell Interface Study

A full cell was fabricated for the study of interfacial characteristics



Fabrication of Full Solid Oxide Fuel Cells

Glycine-nitrate process:

- electrolyte- $\text{La}_{0.8}\text{Sr}_{0.2}\text{Ga}_{0.8}\text{Mg}_{0.115}\text{Co}_{0.085}\text{O}_{3-\delta}$ (LSGMC)
- anode component- $\text{Ce}_{0.5}\text{La}_{0.5}\text{O}_{2-\delta}$ (LDC)
- cathode component- $\text{Sm}_{0.5}\text{Sr}_{0.5}\text{CoO}_{3-\delta}$ (SSC)

Electrolyte: LSGMC Pellet pressed in 1.25" die and sintered to full density

Composite anode: SYT / LDC / LSGMC 0.5/0.4/0.1 wt.

Composite cathode: SSC / LSGMC .7/.3 wt.

Pt paste and mesh used as : current collectors for both anode and cathode



Electrochemical Testing

Electrochemical testing performed on a Solartron® model 1260 and 1480 8-Channel AC Impedance Spectrometer

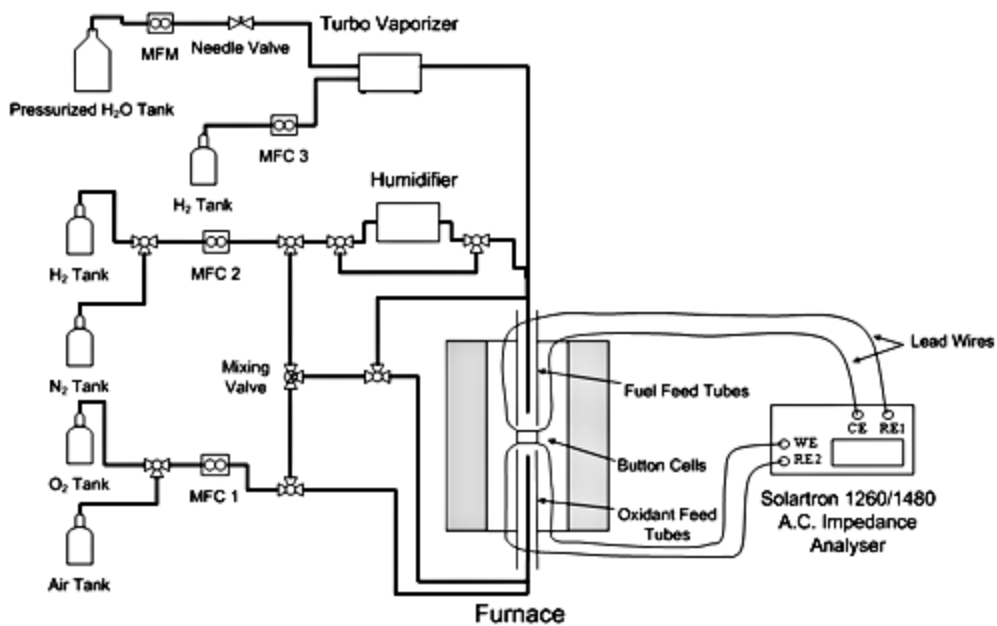
Temperature controlled by an ATS single zone multi-sample split tube furnace

Environment controlled by Brooks® MFCs

- variable fuel and air flows and partial pressures

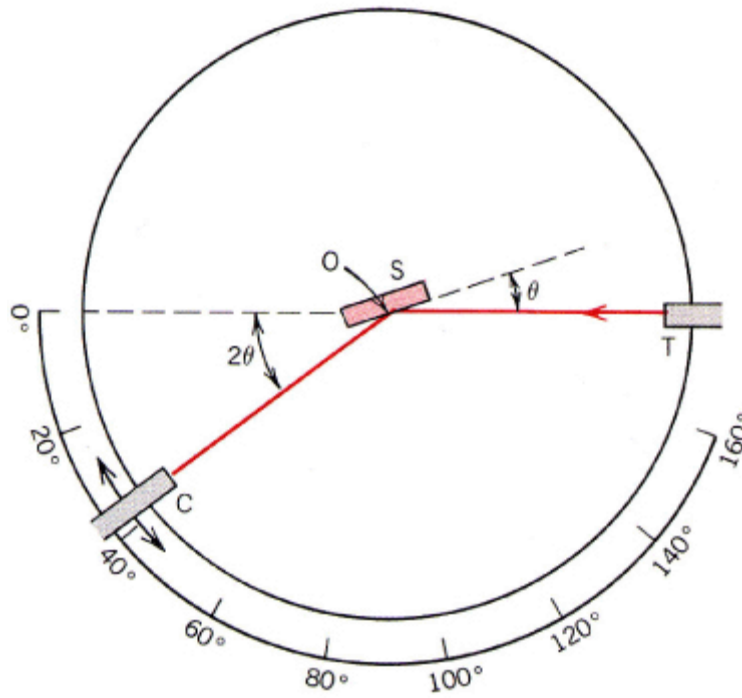


Experimental Apparatus

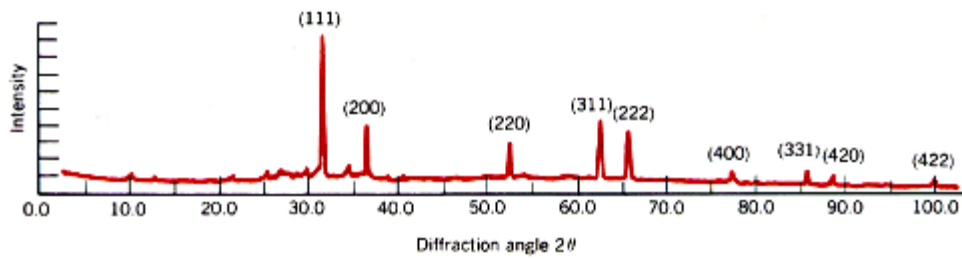


X-Ray Diffraction

X-ray diffractometry allows for the identification of materials based on their structure

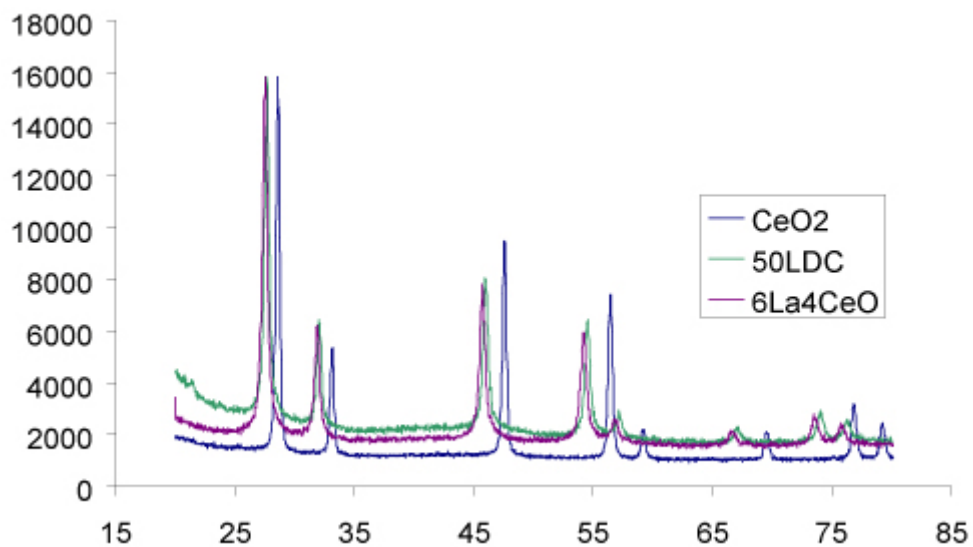


Data is gathered and compared to a library or simulation based on known or predicted parameters

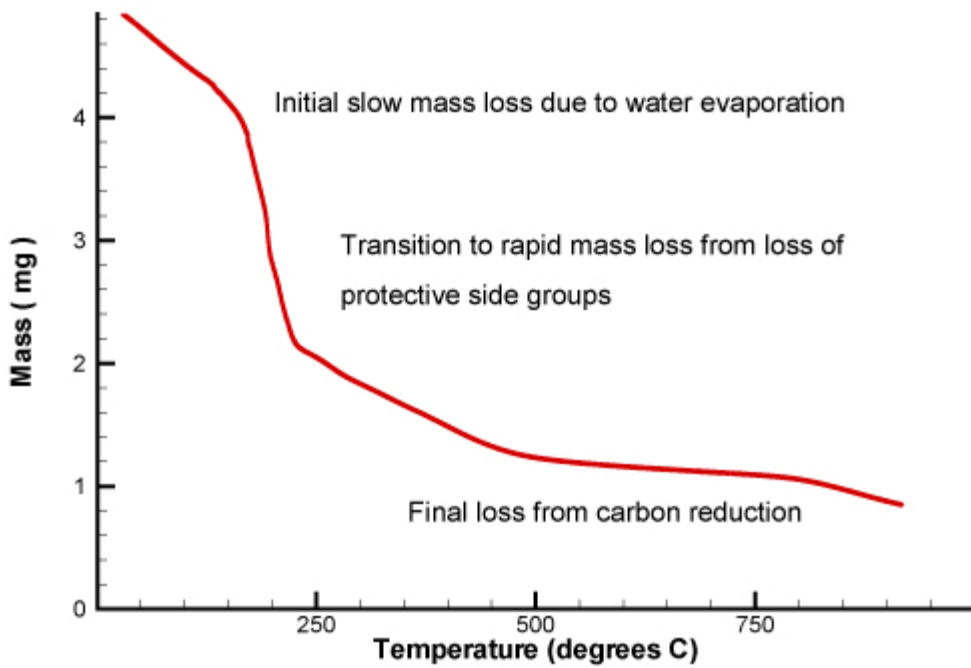


XRD Patterns of LDC Powder

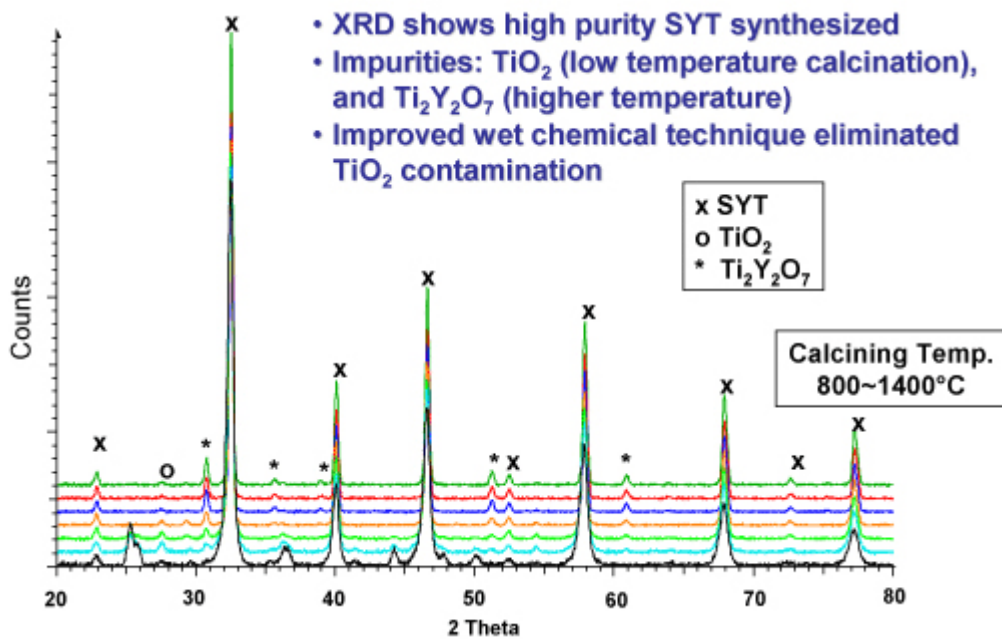
- LDC powder shows expected crystal structure with peaks shifting at higher La doping levels
- No impurity phases observed



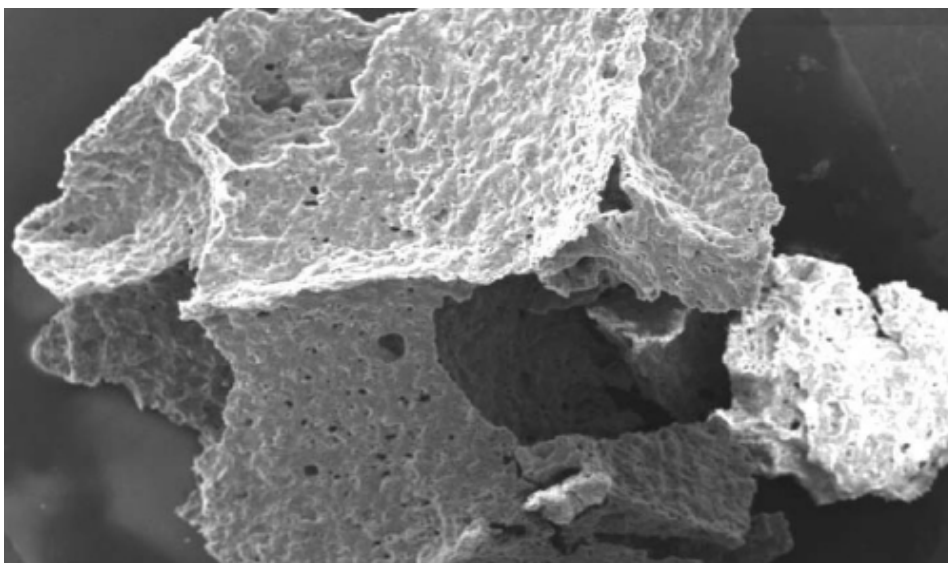
TGA Analysis of SYT Gel



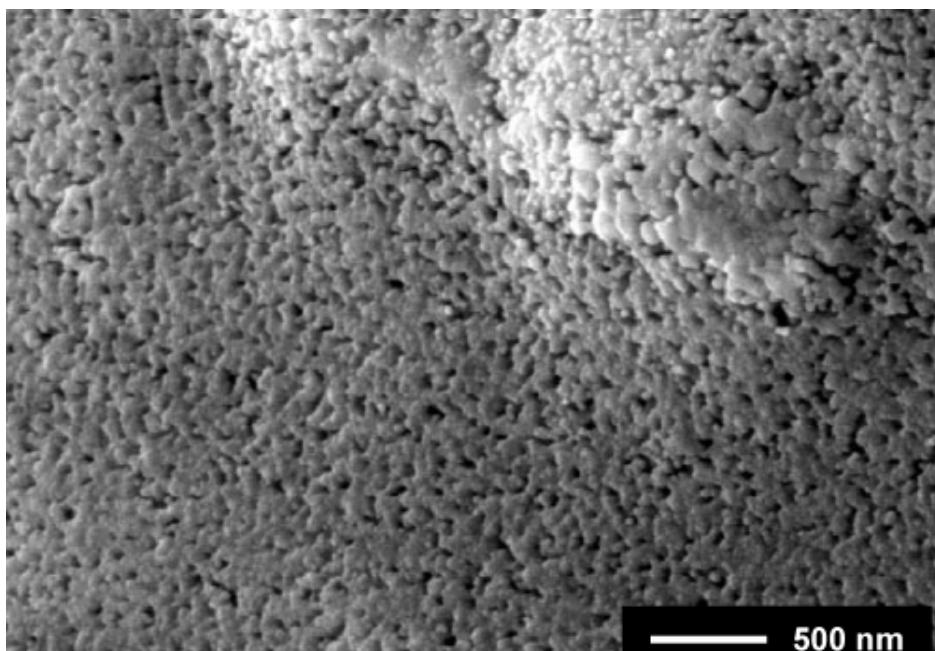
XRD Patterns of SYT Powder



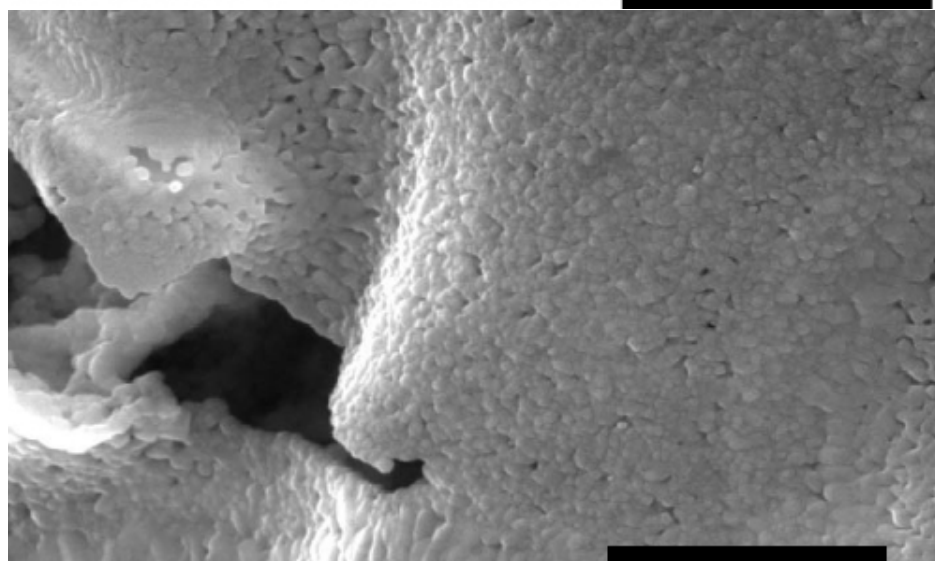
Characteristics of Calcined Foam



1 mm



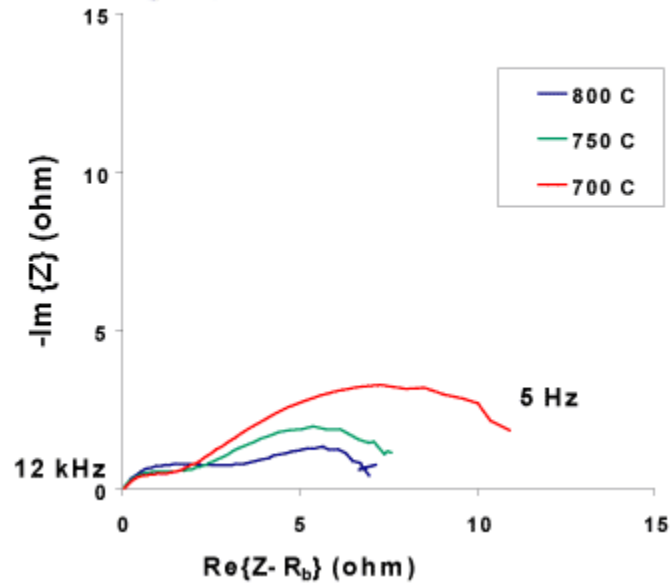
500 nm



500 nm

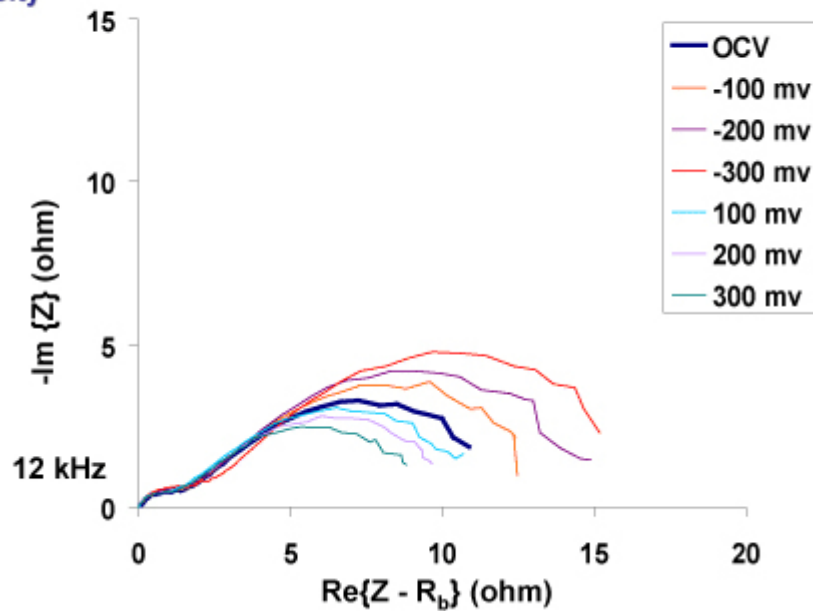
Impedance Spectra of Anode(SYT-LSGMC-LDC) / LSGMC Interface

- under OCV: fuel: dry H₂: oxidant: dry air



Anode Impedance Study

- Polarization study of the anode-electrolyte interface showed increased cathode activation polarization with increasing current density



PERSONNEL

Investigators: X. Lu, J. Brouwer, D. Mumm, and G.S. Samuelsen

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Students: Tom S. Pine

SPONSORS

U.S. Department of Defense, Fuel Cell Program

Edison Materials Technology Center

[1] S. Hui, A. Petric, *J. Electrochem. Soc.*, 149 (2002) J1-J10.

[2] O. A. Marina, N. L. Canfield, J. W. Stevenson, *Solid State Ion.*, 149 (2002) 21-28.