Nano-Tomography of Fuel Cell

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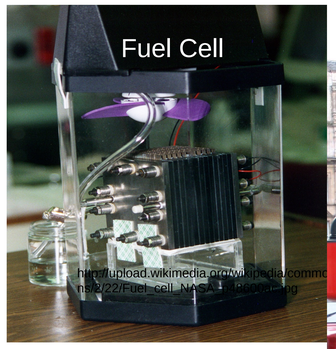
Introduction to Solid Oxide Fuel Cell (SOFC)

Increasing global power demands and environmental concerns have placed growing interest in the development of efficient, scalable, economic, portable, high energy density, and fuel flexible power sources. Solid oxide fuel cells(SOFCs) are considered promised devices to convert energy that exhibit main advantage includes:

- Selective transport of electrons, oxide anions, and fuel/oxidant
- Enhanced electrocatalytic/catalytic activity
- Stability
- Structural support

Solid oxide fuel cells are a class of fuel cell characterized by the use of a solid oxide material as the electrolyte. Fuel cells are powerful resources in remote locations, such as spacecraft. Fuel cells are used in land vehicles, airplanes, boats, and submarines. They are also used in electric and hybrid vehicles, notebook computers, smartphones and small heating appliances.



http://upload.wikimedia.org/wikipedia/commons/2/22/Fuel_cell_NASA_-_Research.jpg

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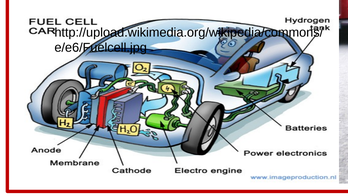
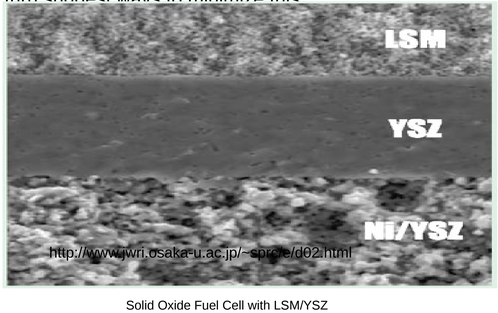


http://upload.wikimedia.org/wikipedia/commons/e/e6/Fuelcell.jpg

The Purpose of the Experiment

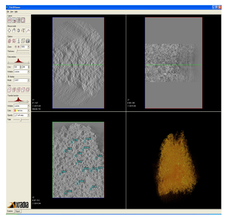
The main purpose we were interested in this experiment was to see if with this technique we can determine changes that occur to the microstructure of a SOFC electrode as a function of heating at elevated temperatures. Electrode degradation (change/collapse of the microstructure) is one of the main processes that influence the performance of a fuel cell. We therefore prepared three sample using the same starting conditions for each (i.e. they all came from the same pellet we made). One was kept as is, the other two were heated at 700 and 1000 C for 10 days respectively. What we are hoping to determine from the data we collected are changes to the porosity, pore size and tortuosity as a function of the difference in heating temperature. This in turn could give us insight in the process involved in the electrode degradation and in turn suggest ways to minimize this.

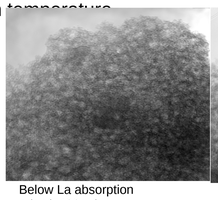


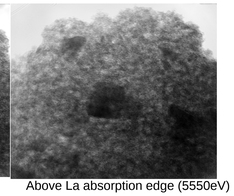
Solid Oxide Fuel Cell with LSM/YSZ layer

Sample Preparation -

The X-ray beam typically probes a 30 micron size portion of the sample. The sample was prepared by Joost van Duijn from Institute Renewable Energy, Univ. Castilla-La Mancha, Albacete, Spain, where we received the sample of SOFC with two different electrolytes layers, yttria-stabilized zirconia (YSZ) and lanthanum strontium manganites (LSM), LSM/YSZ(LSM = La0.8Sr0.2MnO3 , YSZ = 8% Y2O3 ZrO2), under different temperature, (i)1000°C, (ii)700°C, (iii) room temperature.

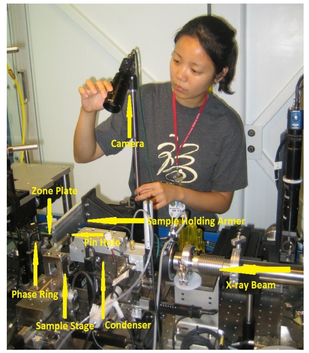

Size of the sample


Below La absorption edge(5400eV)


Above La absorption edge (5550eV)

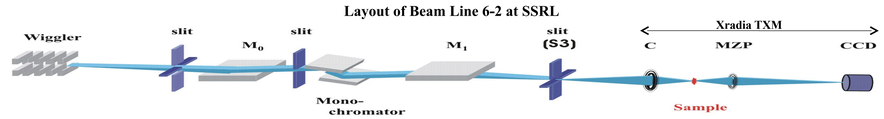
Experiment-

Back in May, the group I am working with at the Stanford Synchrotron Radiation Lightsource at SLAC National Accelerator Laboratory used a nondestructive X-ray tomographic imaging technique (Transmission X-ray Microscopy) to examine the material and the pore networks within an SOFC anode. They acquired images at 5400eV (below Lanthanum (La) L3 absorption edge) and at 5550eV (above La absorption edge). We can see in the mosaic 3x3 images (bin=1 80 sec, right) the pores in the sample SOFC LSM/YSZ layer are much more visible above the La L3 absorption edge. Images were taken at Transmission X-ray microscope Beam line 6-2c SSRL 2010 May 10-12 ZP 30-200/ 324 micron FOV/ 10x

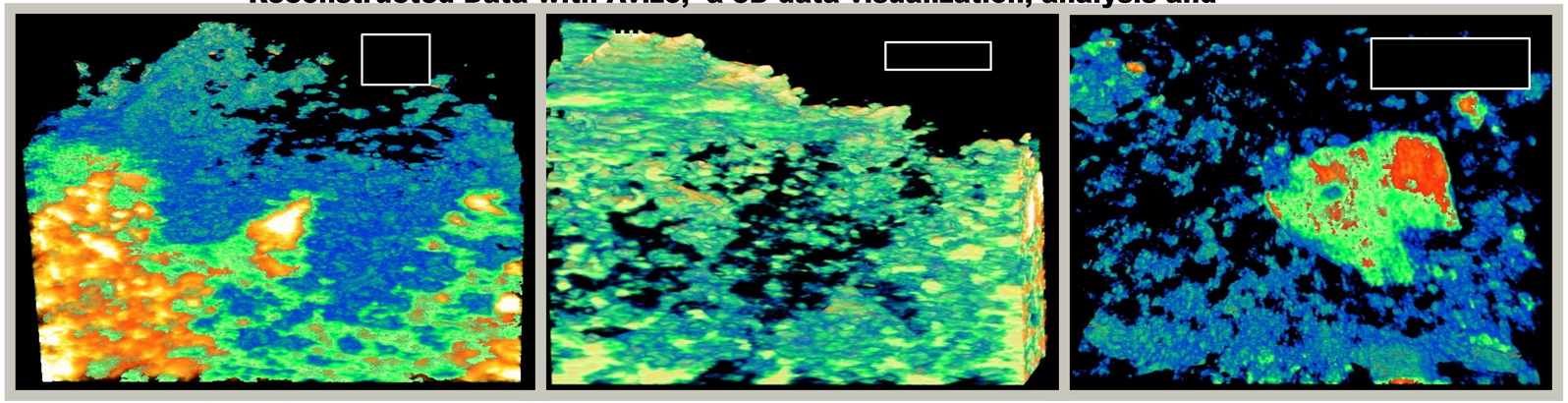


Technique

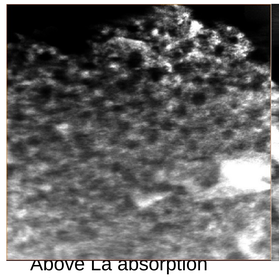
Images were obtained at beam line 6-2 at SSRL, at 5keV in absorption. Tomography was obtained from -65° to +65° for every ½ degree.

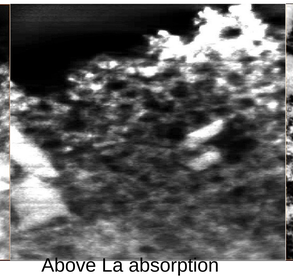


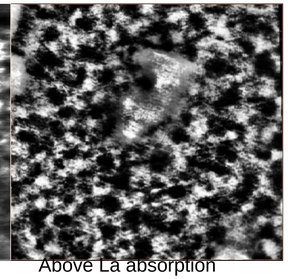
Reconstructed Data with Avizo, a 3D data visualization, analysis and



Data Reconstruction with


Above La absorption edge SOFC LSM/YSZ at 1000°C


Above La absorption edge SOFC LSM/YSZ at 700°C


Above La absorption edge SOFC LSM/YSZ at Room T

Data Analysis with Avizo, Volume Density Percentage

	1000°C	700°C	Room Temperature
Lanthanum Strontium Manganites LSM(LSM = La0.8Sr0.2MnO3)	40.8%	15.2%	12.7%
Yttria-stabilized Zirconia YSZ(YSZ = 8% Y2O3 ZrO2)	49.7%	55.4%	57.7%
Pore (Empty Space)	9.5%	29.4%	29.6%

Conclusion:

The changes to the pore/solid ratio or actual changes to the composition of the electrode (solid) backbone. All three samples are the same as they came from the same pellet. Changes in the porosity can tell us what is happening to the microstructure. It seems that the pore/solid ratio stays consistent regardless to the changes of the temperature. However, as we can see from the chart; the porosity of pore seems to decrease at temperature at 1000°C.

Acknowledgement -

The author is grateful to the staff of the Stanford Synchrotron Radiation Laboratory (SSRL) facility, in particular Yijin Liu and Joy Hayter. The sample was prepared by Joost van Duijn from Institute Renewable Energy, Univ. Castilla-La Mancha, Albacete, Spain. The transmission X-ray microscope (TXM) is funded by National Institute of Health (NIH). The data was collected at beam line 6-2 at SLAC National Accelerator Laboratory, a national user facility operated by Stanford University on the behalf of the Department of Energy. The author also thank STAR program through Caly Poly for the opportunity and the support.