An Efficient Way for Electricity Production: Solid Oxide Fuel Cells

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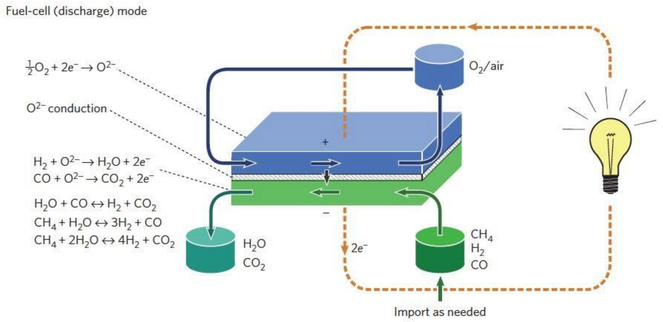
Objective:

To determine the effect the porosity of a Nickel Oxide-Yttria Stabilized Zirconia(NiO-YSZ) anode has on the performance of a solid oxide fuel cell (SOFC).

Background

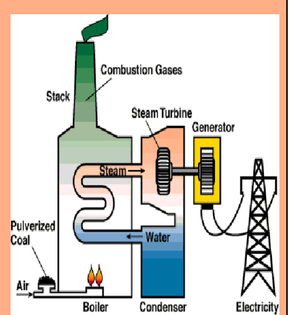
- Solid Oxide Fuel Cells are electrochemical devices that use the reaction between oxygen ions and hydrogen to produce electricity, water, and heat.
- A solid oxide fuel cell consists of a cathode, an oxygen ion conductive electrolyte, and an anode.



http://www.nature.com/nmat/journal/v14/n2/full/nmat4165.html

Why Fuel Cells?

- The fuel cells are used as an efficient way to way to produce electricity, with little to no emission of greenhouse gases, no corrosion, and low cost. They have long term stability and fuel flexibility.
- However, they must be operated at high temperatures, which means longer start up times and thermal stress.
- In the current process for generating electricity, chemical energy is converted to thermal energy, which is converted to mechanical, and then electrical. This process loses a lot of energy as heat.



http://astarmathsandphysics.com/ib-physics-notes/119-energy/1292-electrical-power-production.html

- Fuel Cells go through a direct conversion from chemical to electrical energy and reuse the heat from the oxidation reaction to keep the high temperature operation of the cell.

Methods

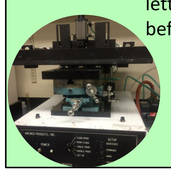
The anode material was manipulated, and the cathode and electrolyte were kept constant. The effect of porosity was being determined using carbon black in the anode. Carbon Black is an organic material that reacts with the air in the sintering process, and no longer is part of the anode during testing. This means that the anode with carbon black is porous.

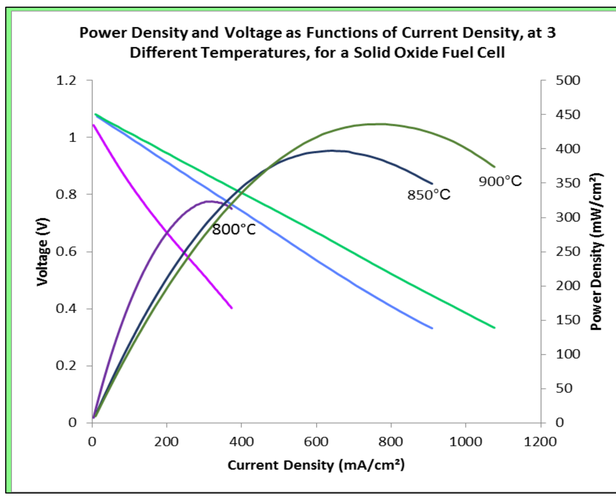
1. Measure the Chemicals.
- Lanthanum Strontium Manganite (LSM), YSZ, and Carbon Black for the cathode.
- Nickel Oxide and YSZ for the anode. One anode with Carbon Black.

2. Combine the anode or cathode chemicals in a bottle with alcohol. Add milling balls, and put the bottle on the milling machine.

3. Make the Inks: Let the mixture dry in the oven and mill it into a powder, using a milling bowl. Add solvent and put it into the ball milling machine to make ink.

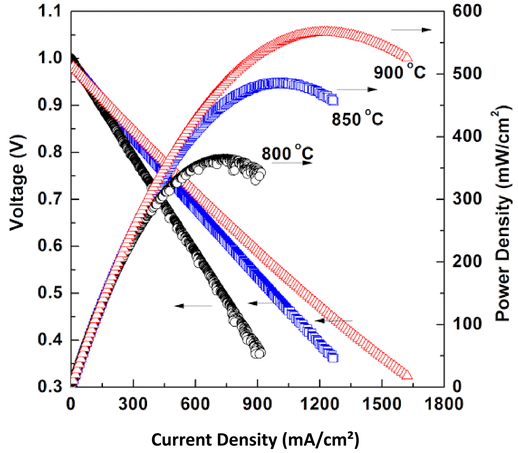
4. Paste the inks on the electrolyte: Use the screen printer to print the cathode and anode inks on the YSZ electrolyte, letting one side dry before pasting the other.





Results

To the left is the graph showing the performance results for the SOFC with the porous anode (or with carbon black) at three different temperatures, 900°C, 850°C, and 800°C. As you can see, the higher temperature curves have higher peak values for power density and higher current density values at those peaks. The graph also illustrates that as current density increases, the voltage of the cell decreases.



Results Cont'd

To the left is the graph for the SOFC with the non-porous NiO-YSZ anode. The same relationships are shown in this graph. However, the peaks for the power density have higher values than that of the porous anode and the current density is higher at those peaks than that of the porous anode.

Conclusion

According to the data, the SOFC with the non-porous anode has a higher performance, as the power density and current density values are higher for it than those of the cell with the porous anode.

However, theoretically the cell with the porous anode should have a higher cell performance, since porous materials have more surface area and therefore more sites for the oxidation reaction to happen. Porosity also allows for the fuel(hydrogen) to travel to the oxygen ions, letting the reaction happen more readily. Hence, the results that we got were unexpected.

A possible explanation for why the performance of the porous anode cell was lower than expected is that the cell was not flat when sealed. If the cell is not flat there is not proper contact between the anode of the cell and the gold current collector connecting to the circuit. This has a large impact on the performance of the fuel cell because it increases resistance.

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