Impact of Fuel Contaminants on Performance in Coal-Based SOFCs

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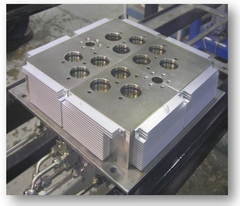
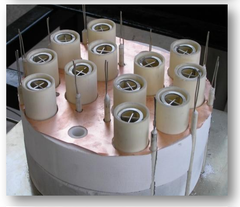
PROJECT GOAL: To increase the efficiency of SOFC testing efforts with the ability to test twelve cells at a time. Testing can occur in either a laboratory setting with simulated syngas or at any gasifier site with direct syngas.

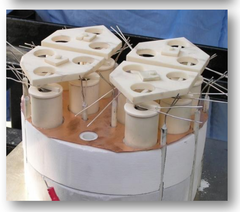
Direct Syngas Testing at NCCC-PSDF in Wilsonville, AL

The SOFC MCA being installed by an NETL researcher at the NCCC-PSDF facility in Wilsonville, AL

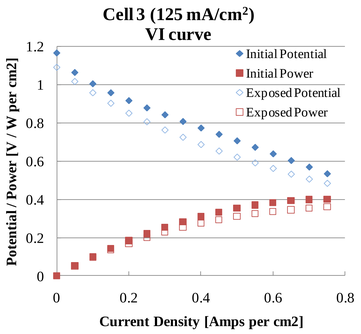
- The Multi-Cell Array (MCA) is a portable SOFC test fixture capable of testing twelve SOFCs under the same fuel conditions. The whole fixture is mobile, allowing it to be deployed to any remote gasifier location and test cell operation on direct coal syngas
- The MCA project has been successfully deployed to the NCCC/PSDF facility in Wilsonville, AL on two occasions to test SOFC operation with their partially cleaned syngas (July/August 2008 and September 2009)
- In 2008, the system was operated for 200 continuous hours on partially cleaned direct syngas. Six cells were operational for this test, with three loaded at 50mA/cm²
  - The syngas contained very low levels of contaminant, likely due to adsorption within the hydrocracker, making a second test of "dirtier" syngas desirable
- In 2009, the system was operated for 450 hours, with eight cells surviving the duration of the test. The syngas was not put through the hydro-cracker in this case

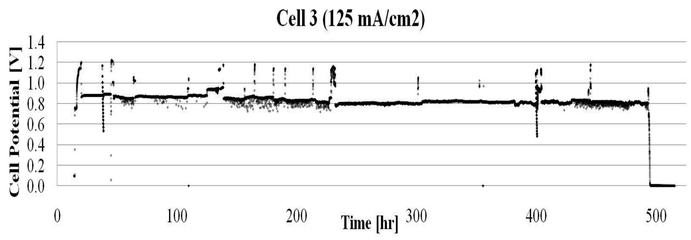






Results





- Eight of twelve cells operated for the duration of the 450 h exposure. The cells were operated at current densities of 0, 125, 250, and 375 mA/cm².
- Degradation was accelerated as the current density increased
- The figure above shows the potential as a function of time while the figure on the left shows the decrease in performance at the beginning and end of syngas exposure

Estimated Cell Degradation Rate	
OCV	9.3% per 1000 h
125 mA/cm²	9.7% per 1000 h
250 mA/cm²	12% per 1000 h
375 mA/cm²	23% per 1000 h

Two primary effects of current density (postulated):

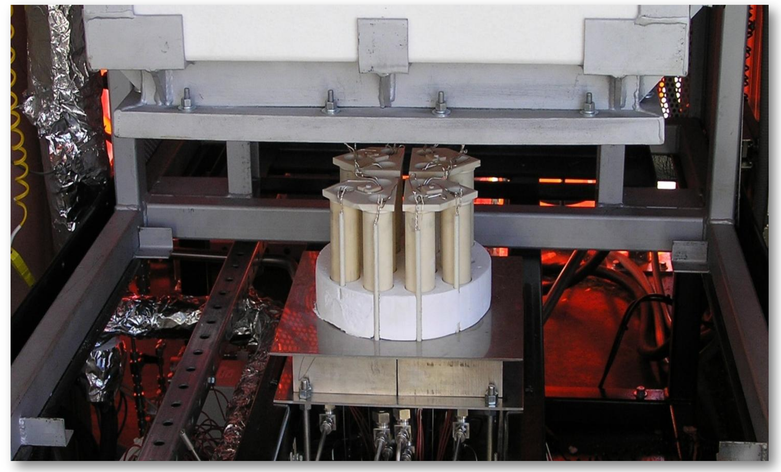
1. Promotes generation of secondary phases at interfaces
2. Supports oxidative removal of surface adsorbed species

3 Primary Degradation Classes

Class I: Pore blockage (particles, coke)

Class II: Surface and TPB adsorption (sulfur)

Class III: Solid state reactions
- **III A:** Secondary phase formation
- **III B:** Solid solution formation

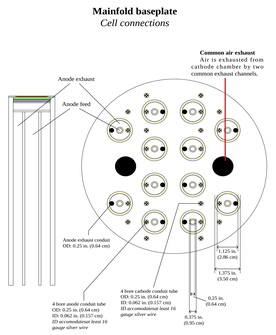


- Thermodynamics predicts that at warm gas cleanup conditions, the elements As, Cd, Hg, Pb, Sb, and Se will be present in vapor form
- It is known from laboratory testing that As and Sb will react with the nickel in the SOFC anode to produce secondary phases, however there is very little data on cells fueled with direct syngas
- This test was conducted while coupled with a GC-ICP/MS analytical system to determine trace metal concentration within the syngas
- Higher hydrocarbon concentration was determined by IR analysis* to include the following HHCs

	Ethane	Propane	Ethylene	Benzene	Naphthalene	Ammonia
Mean [ppm]	19	10	32	450	130	1700
SD [+/- ppm]	14	6	32	160	52	440
Max [ppm]	48	25	90	660	200	2200
Min [ppm]	1	4	0	210	42	1000

On-site Testing and Capabilities

- The MCA expands NETL's testing capabilities to better aid other research groups, both on and off site.
- Research groups are able to test their novel cathode materials, infiltrated cathodes, and homemade SOFCs all under consistent fuel composition and temperature.
- Seal-less design eliminates the need for metal contact pastes that may alter the cell's performance by infiltration.



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