Solid Oxide Fuel Cell Carbon Sequestration

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with Support of NiSource Energy Technologies

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PDP-43

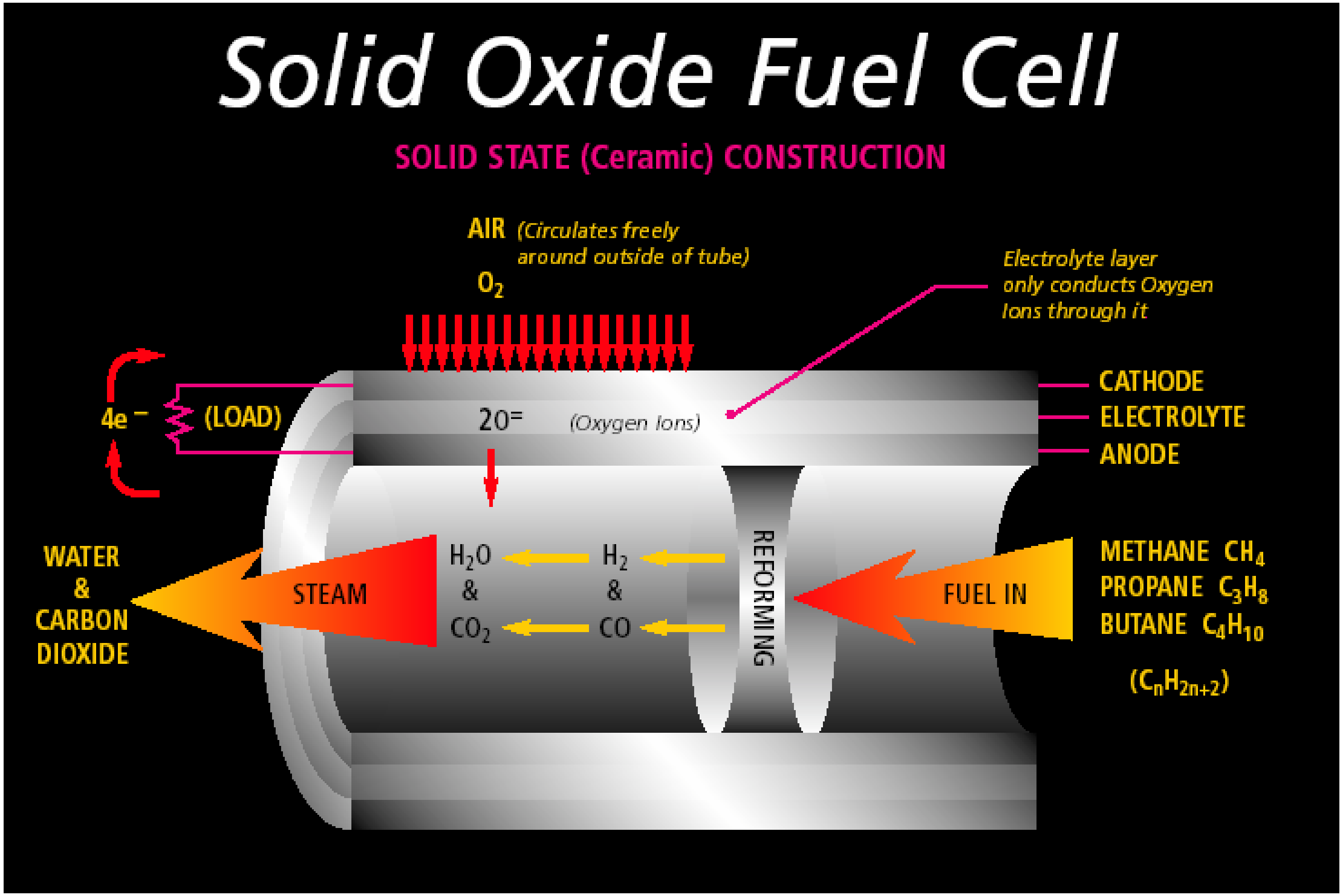
Overview

- Timeline
  - –Project Start: November 6, 2004
  - –Project End: September 30, 2007
  - –80 % Complete
- Budget
  - –Total Project: $2,049,000
  - –DOE Share: $1,639,000
  - –Contractor Share: $410,000

Project Objectives

- The objective of the project is to develop the technology capable of capturing all carbon monoxide and carbon dioxide from a natural gas fueled Solid Oxide Fuel Cell (SOFC) system.
- In addition, production of a higher performance cell will also lead to cells with increased efficiency thus limiting the remaining carbon monoxide the needs to be electrochemically oxidize to carbon dioxide will be developed.
- Success of this R&D program would allow for the generation of electrical power and thermal power from a fossil fuel driven SOFC system without the carbon emissions resulting from any other fossil fueled power generation system.

How Acumentrics Fuel Cells Work



Acumentrics Fuel Cell Evolution

Stackable Single Chamber Manifold design

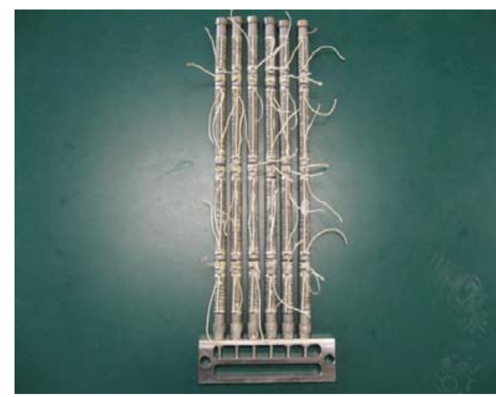
20 Watt Tubes
2005

Stack Design Attributes

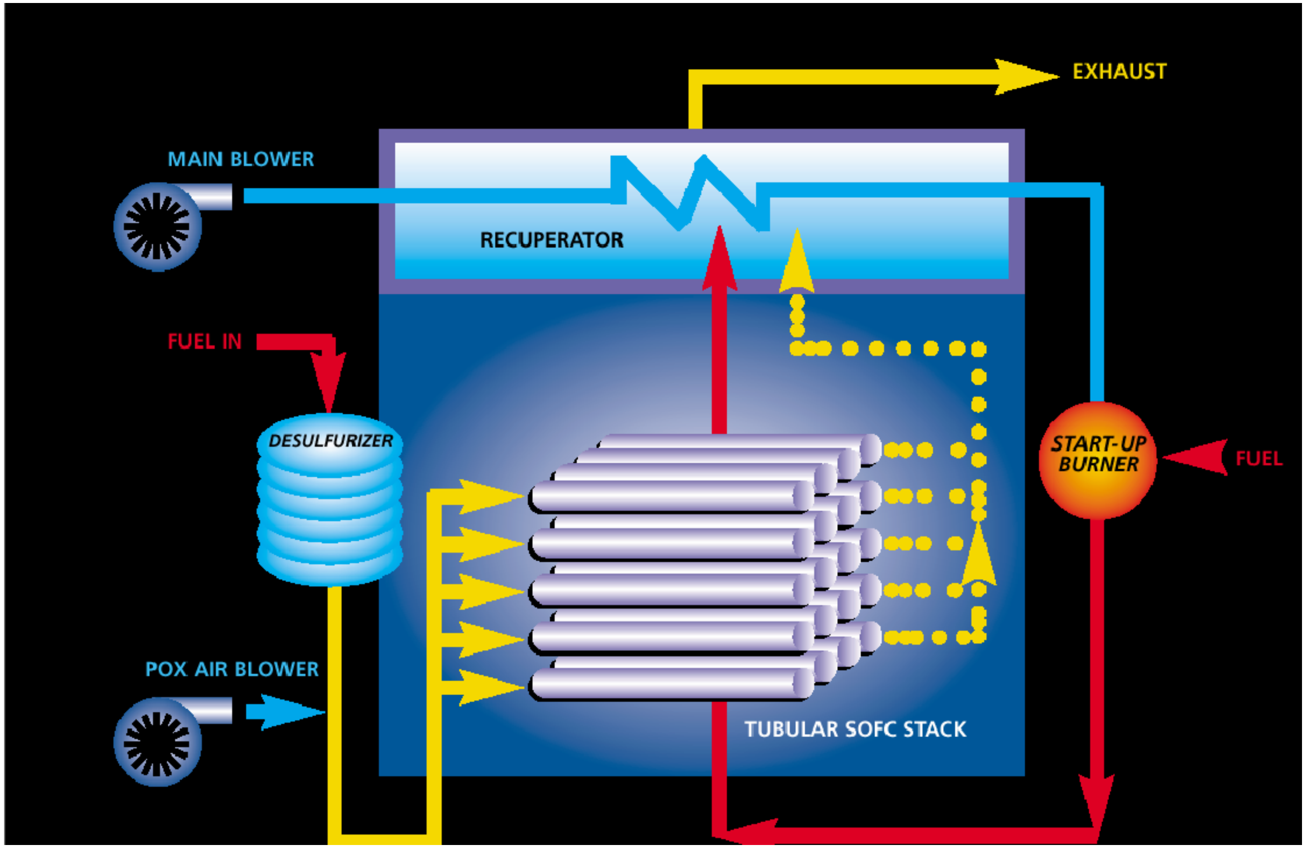
- Anode support tubes
- Brazed seals
- Stackable design
- Welded electric connections
- Low thermal mass
- Withstands heat expansion

High Power Anode Tubes

40 Watt
Tubes
2006



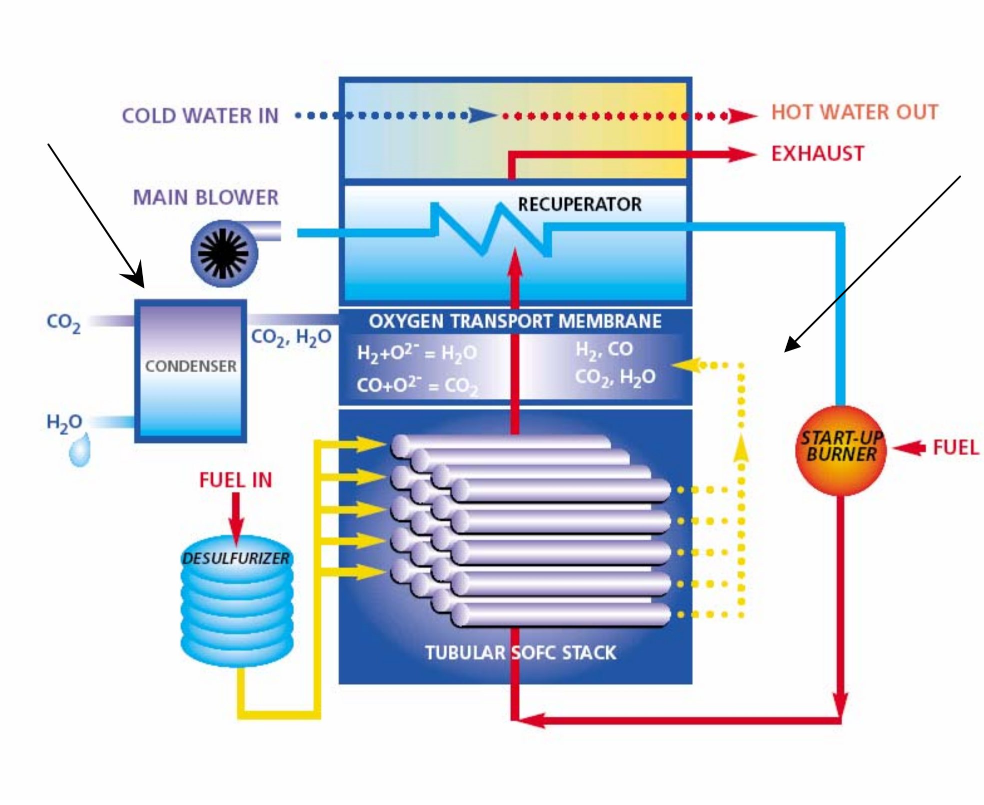
Acumentrics Tubular SOFC System Overview



In the existing generator design, the non-electrochemically used fuel is combusted with the air and exhausted to the atmosphere

Conceptual layout of a CO_2 Sequestered SOFC Generator

The CO_2 & H_2O are then passed across a condensor removing the water leaving a pure CO_2 stream



In the conceptual design, the non-electrochemically oxidized fuel is passed to a set of ceramic membranes which fully oxidize the remaining fuel.

Approach

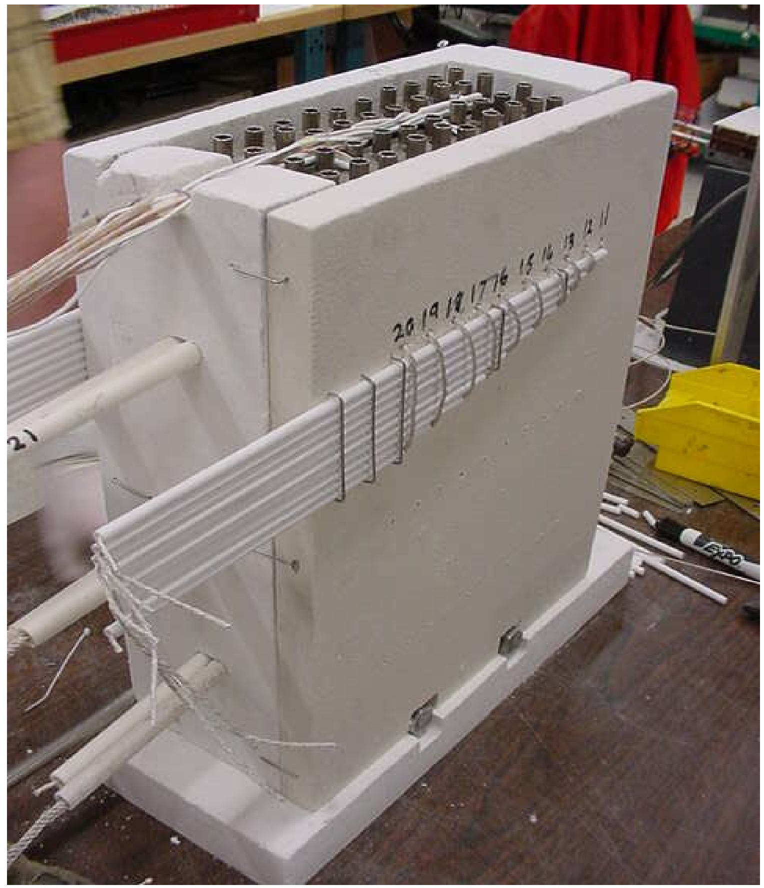
- There are two key developments needed to successfully complete this research:

1. Increase the sealing techniques of the stack manifolds to increase overall efficiency.
2. Fabricate higher performance cells with interconnects to increase efficiency and complete the oxidation of the spent fuel to result in an exhaust stream containing only carbon dioxide and steam.

Technical Accomplishments
1. Capturing Utilized Fuel

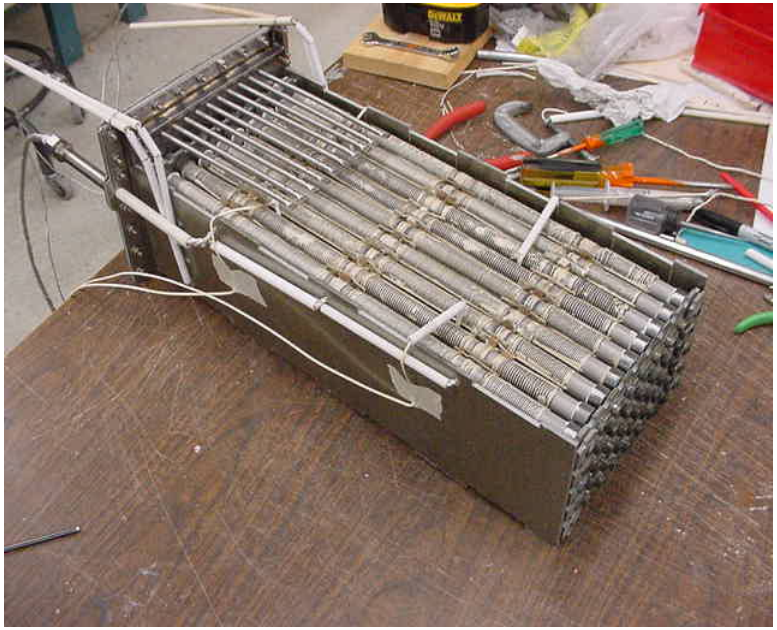
- An alternative vertical stack configuration and a single manifold stack design has been developed that can potentially provide operational, performance, packaging, efficiency and ruggedness advantages over the cantilevered, horizontal cell stack geometry.

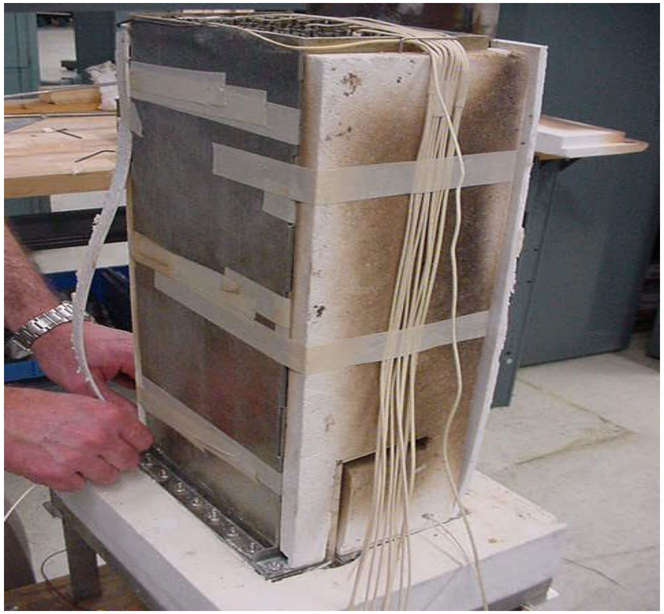
Double Manifold Vertical Stack Assembled



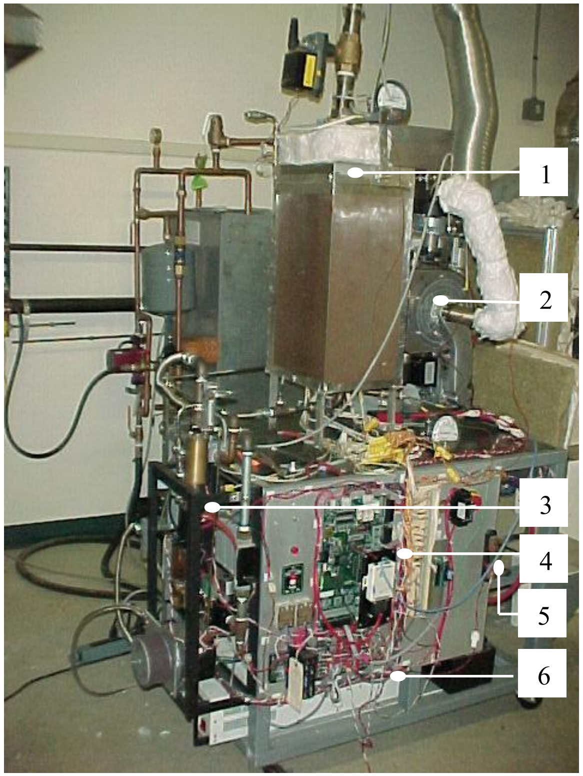
Vertical Stack Bundle with Single Fuel Manifold

- High efficiency, high packing density, and sintered bundle stack configuration
- 45 cell sintered bundles produced a maximum output power of 1118 W a voltage of 26 V.





Vertical Test Stand Configuration



SYSEM SUB-ASSEMBLIES

1) 1kW Fuel Cell Hot Module

2) Gionnini Water Heating Coil

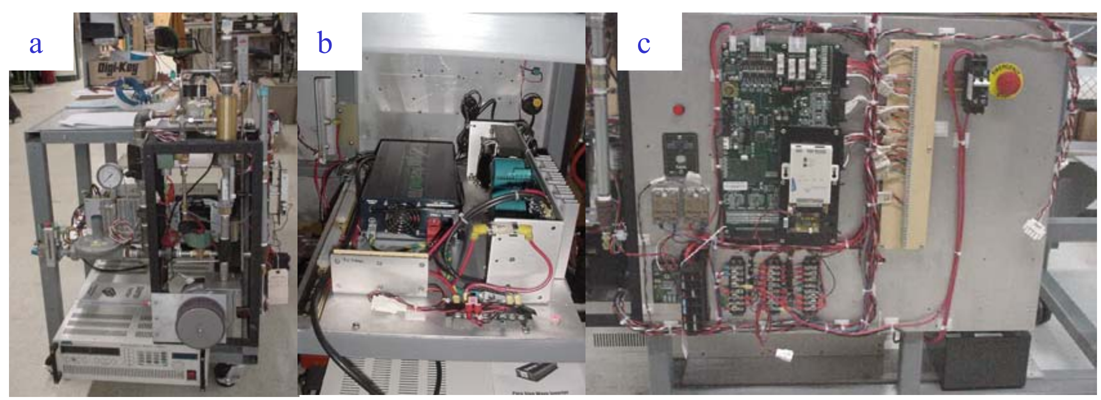
3) Gas Utility Module

4) Controller Board Panel

5) Power Electronics Panel

6) DC Load Panel

Test Stand Sub Assemblies



Test Stand (a) GUM, (b) power electronics and (c) control electronics

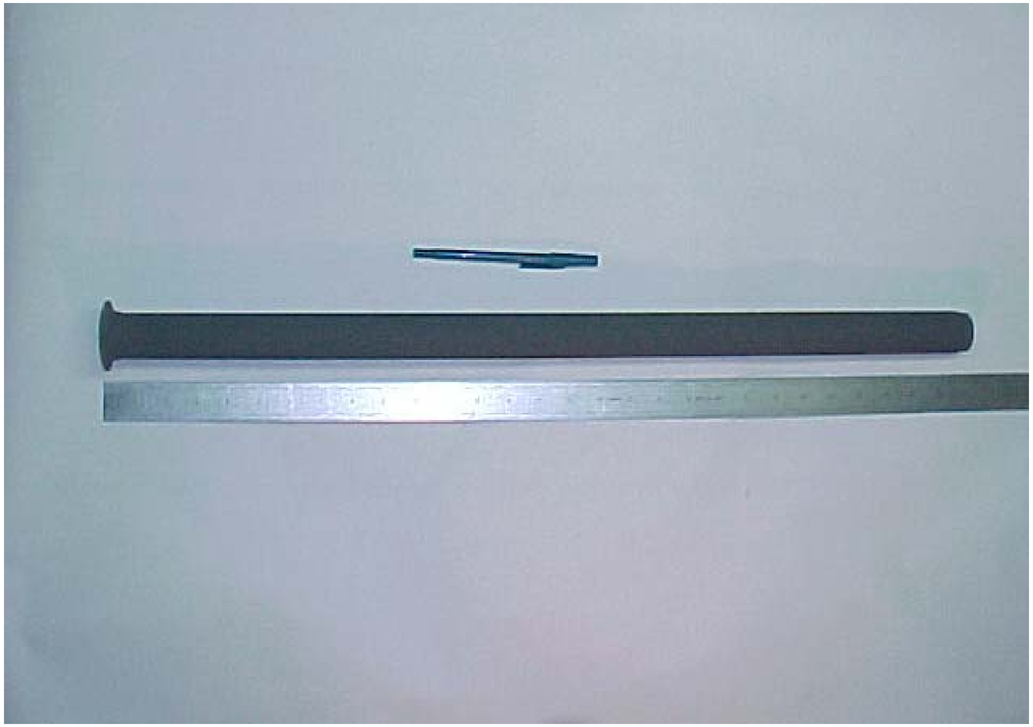
Technical Accomplishments

2. Fabrication of Iso-statically pressed cells

- Processing closed end tubes produced by iso-statically pressing and plasma spraying for oxygen transport membranes/cells has progressed to potentially lead to a viable OTM and cells with increased efficiency.

Closed One End Tube (COE)

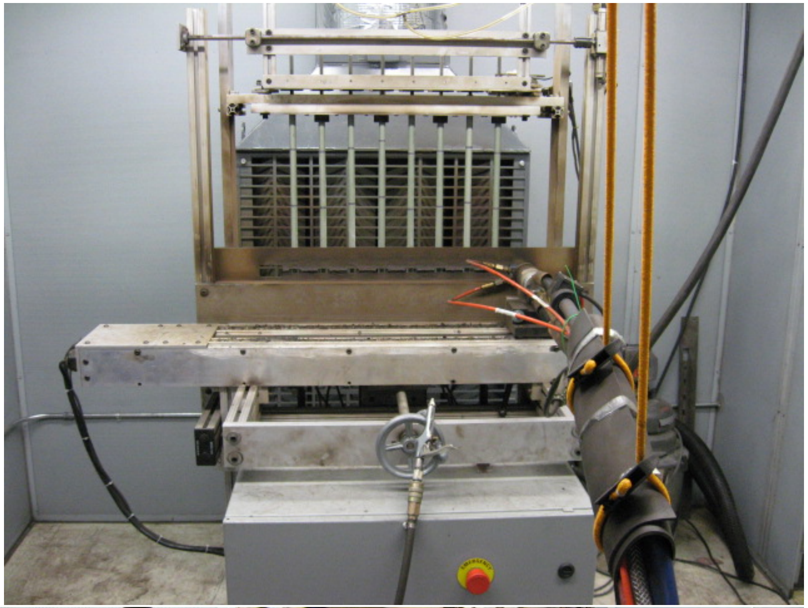
- Green tube fabricated by Isopressing



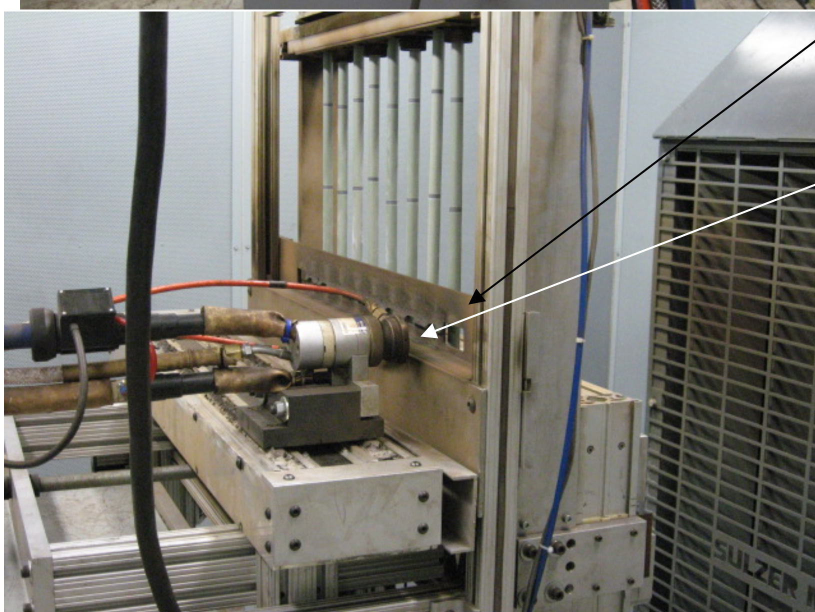
Sintering COE Tubes

- Hang sintered using the same technique as the bisque firing

Plasma Spray Robot

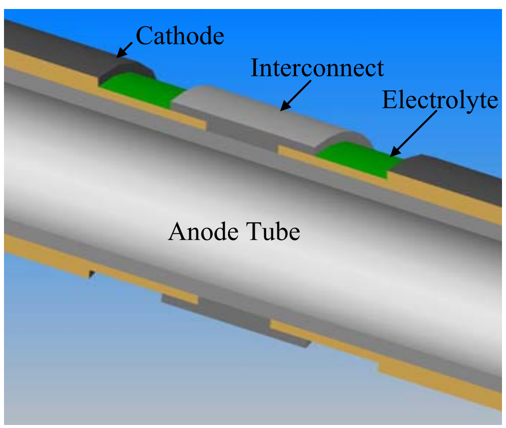


- Ability to spray different size cells
- Test different OTM/cell designs to increase and optimize efficiency

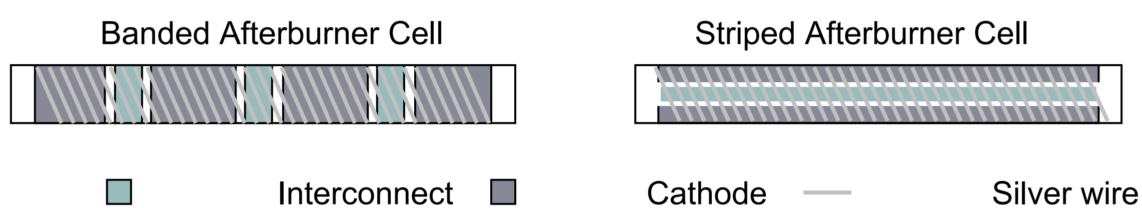


OTM/Interconnect Design

- Plasma sprayed interconnect layer
  - Dense interconnect prevents gas transport
  - Allows electrons to easily pass from cathode to anode
  - Oxygen ions continue to pass through the electrolyte later



Cross-sectional diagram of Interconnect Cell prior to silver winding



Future Work

- Developments

1. High Density and Efficient Cell Bundles
   - Evaluate a isolated braze cap that will prevent the cell from shorting to a single fuel manifold.
   - Test and evaluate new materials to seal and isolate braze cap
2. Steam Reformation
   - Develop steam reformation through off gas recirculation to increase overall efficiency
   - Develop high temperature recirculator to recover Co_2 stream
3. Isostatic Tube Processing and Plasma Spraying
   - Develop plasma spray process and test cells for performance
   - Optimize firing programs to achieve desirable material properties
   - Spray potential OTM materials and evaluate