

IV.H.10 Large Area Cell for Hybrid Hydrogen Co-Generation Process

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Subcontractors:

Idaho National Laboratory, Idaho Falls, Idaho

Hoeganaes, Cinnaminson, NJ

University of Washington, Seattle, WA

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Projected End Date: April 30, 2008

Objectives

Process Objectives

- Direct production of hydrogen suitable for polymer electrolyte membrane (PEM) fuel cells (no shift or CO removal required)
- Co-generation of hydrogen and electricity using a hybrid SOFC/SOEC stack
- Eliminate the partial oxidation penalty (high Faraday and Nernst efficiencies)
- Thermal management by in stack process integration
 - Temperature/resistance uniformity across cell
 - Reduced thermal stress
 - Reduced cooling air flows and preheat duty
 - Enable large area cells
- Design flexibility for selective energy partitioning, H₂:electric power
- Enable CO₂ sequestration by generating non-condensable free exhaust

Project Objectives

- Demonstrate porous metal supported solid oxide fuel cell/solid oxide electrolysis cell (SOFC/SOEC) design and fabrication process
- Optimize alloy composition and process parameters for cell life and performance
- Demonstrate cell at scale larger than achievable using ceramic processing route

Technical Barriers

This project addresses the following technical barriers from sections 3.1.4.2.1 (Distributed Hydrogen Production from Natural Gas or Renewable Liquid Feedstocks) and 3.1.4.2.2 (Hydrogen Generation by Water Electrolysis) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program (HFCIT) Multi-Year Research, Development and Demonstration Plan:

- A. Fuel Processor Capital Costs
- E. Carbon Dioxide Emissions
- G. Capital Costs
- H. System Efficiency
- G. Grid Electricity Emissions
- J. Renewable Integration
- K. Electricity Costs

Technical Targets

Co-generation of high purity hydrogen by high temperature electrolysis, and electricity using a SOFC in a single hybrid electrochemical device addresses several key targets for hydrogen production from natural gas or renewable liquid fuel feedstocks, as well as water electrolysis in the HFCIT Multi-Year RD&D Plan. The hybrid SOFC/SOEC stack design yields a higher overall efficiency (combined electrical generation and hydrogen generation) than would be achievable using similar technology to generate only hydrogen or electric power. Whereas in a conventional SOFC generator, thermal management (rejecting waste heat) increases the system capital cost and reduces system efficiency by requiring a large air heat exchanger and blower with its associated parasitic power load, the hybrid system provides a valuable byproduct - hydrogen, or electric power depending on which is the primary desired product. The specific thrust of this project is to develop a cell design and fabrication process enabling production of very large area cells to exploit the thermal management benefits of the hybrid cycle. The availability of large, low-cost cells will significantly reduce the capital cost of the stack. The fact that this design can directly produce ultra high purity hydrogen, without the need for shift and CO removal operations, will also result in significant capital cost savings. The combination of lower capital cost, high purity hydrogen production, byproduct electric power production, and an exhaust stream suitable for CO₂ sequestration will result in a significant reduction in the cost of hydrogen from natural gas, or bio-derived renewable liquid fuels.

Approach

Large area cells, suitable for use in high temperature steam electrolysis or near thermal neutral hybrid SOFC power and hydrogen cogeneration systems, will be produced by automated thermal spray deposition onto a porous metal substrate. Porous stainless sheets, made using powder metallurgy (P/M) techniques such as direct powder rolling or calendaring of gravity filled molds, are commercially available in thicknesses from 0.25 mm to 3 mm and widths up to 1m. The P/M sheet can be sheared, rolled and welded much like conventional alloy sheet. Porous metal sheet in this thickness and size range is a good size match to that desired for the large area cells enabled by the hybrid stack technology and needed for the 500 kW and 1,000 kg H₂/day stacks desired for power park applications.

The team, consisting of Ceramtec, Hoeganaes, INL, and the University of Washington, will combine their respective areas of expertise to create a new type of cell using the P/M substrate. The initial development effort will use 10 cm square cells for compatibility with the testing infrastructure at Ceramtec. Ceramtec will draw on its technology in metallic interconnects to specify alloy chemistry and surface treatments to Hoeganaes, who will produce the required custom heats of metal powders. Hoeganaes will work with

Ceramatec to convert the powders to porous sheet metal. INL will use their automated thermal spray process development facility to deposit Ceramatec-synthesized electrochemical materials for the anode, electrolyte and cathode onto the P/M substrate. Ceramatec and the University of Washington will work together on alternative electrolyte deposition processes such as controlled atmosphere constrained sintering. Electrochemical testing will be performed by Ceramatec. Each of the four team members will carry out analytical examination (scanning electron microscopy, etc.) of the resulting structures according to their respective areas of emphasis. The fabrication and evaluation cycle will be repeated; varying the chemistry, coatings, and microstructure of the substrate and active layers, and verifying progress toward the objectives of improving performance, life and ease of production by electrochemical testing.

Accomplishments

The project is in its initial stages of issuing subcontracts and ramping up work on the preparation of initial substrate materials needed before the larger effort is started.

- Several heats of powder metal have been produced
- A reactive element addition calibration and analysis capability have been established.