System Design and New Materials for Reversible Solid-Oxide, High-Temperature Steam Electrolysis

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GE Global Research

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Project ID #: PDP42

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DE-FC36-05GO15024

Overview

Timeline

Project start date: TBD

Project duration: 3 years

Percent complete: Contract has not started

Budget

Total project funding:

DOE share:

Contractor share:

Funding for FY05: TBD

Hydrogen Generation by Water Electrolysis

Barrier K. Electricity costs

High-temperature solid oxide electrolysis can use lower cost energy in the form of steam for water splitting. Electrolysis systems that can produce both hydrogen and electricity must be evaluated.

Partners

Northwestern University

Functional Coating Technologies, LLC

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Objective

Develop a pilot scale, reversible SOEC system design

capable of 1000 kg/day H_2 production at $2/kg

based on new, low-cost, reversible solid oxide electrodes

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Approach

Project Team

GE Global Research

System Modeling, High Temperature Ceramics, High Throughput Screening, and Electrochemistry

Northwestern University

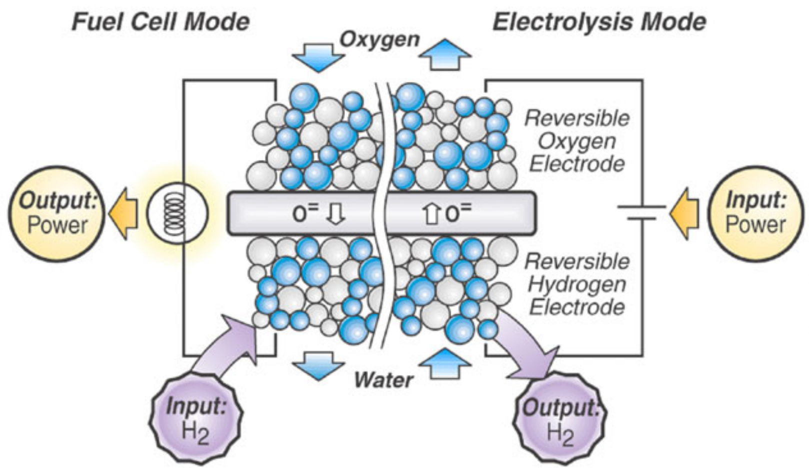
Novel Solid Oxide Materials, Mechanisms, and Characterization

Functional Coating Technology, LLC

Ceramic Materials Processing

Program to Develop Reversible Electrode Materials for Solid Oxide High Temperature Steam Electrolysis

Program Objectives: *To develop reversible electrodes and system designs for low-cost production of hydrogen and electricity using solid oxide technology.*



Technical Approach

- Cost model for reversible H_2-electricity
- Materials discovery
- Electrode microstructure/ interface optimization
- Novel microstructure characterization tools
- Electrode performance and durability maps
- Microstructure-based failure modeling
- Systems heat and mass transfer modeling
- Optimized pilot-scale design

Program Deliverables

- Low-cost, reversible electrolysis/fuel cell electrode materials
- Pilot-scale system designs to achieve hydrogen production cost of \$2.00/kg scaled to 1000 kg/day system

Benefits

- Enables distributed production of hydrogen and electricity in renewable power parks
- Screens large material space to identify electrodes for efficient electrolysis
- Integrates materials performance in system designs for optimized system
- Produces predictive capability for assessing long-term operation and stability of materials

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System Approach

Design a pilot scale system achieving $2/kg hydrogen production cost

- Develop a cost model for reversible hydrogen/electricity generation
- Produce a comprehensive heat and mass transfer systems model
- Design an optimized pilot-scale system

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Materials Approach

Develop low cost, reversible electrode materials

- Design electrolysis electrocatalytic materials for reversible SOEC electrodes
- Optimize electrode microstructures
- Optimize thin-electrolyte, reversible electrolysis cells
- Map reversible electrode performance and degradation within the system operating space determined by the system design
- Develop microstructure-based performance and failure modeling allowing predictive capability for assessing long-term operation and stability

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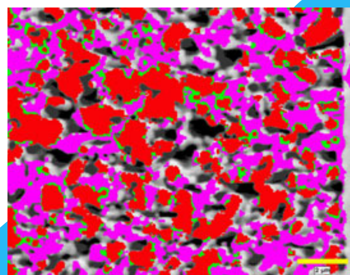
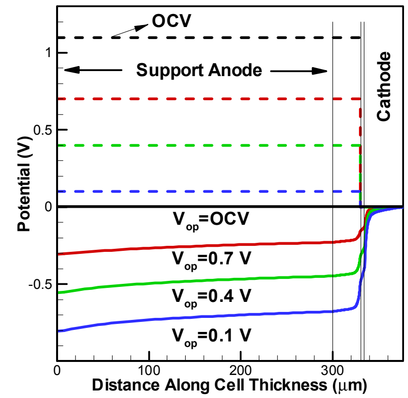
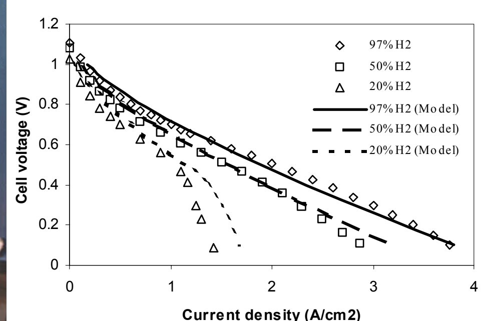
Materials & microstructures



Modeling



Reversible Electrode Development



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Performance and durability

Future Work

Project Year 1

System

- **Results from cost model**
- **DP: Target cost of H2 < $2/kg achievable?**

Performance

- **Baseline materials durability and performance**

Materials

- **Optimize microstructures**
- **New oxygen electrode materials**

NU

- **Advanced characterization methods**
- **Accelerated testing methods**

FCT

- **Button cell fabrication processes**

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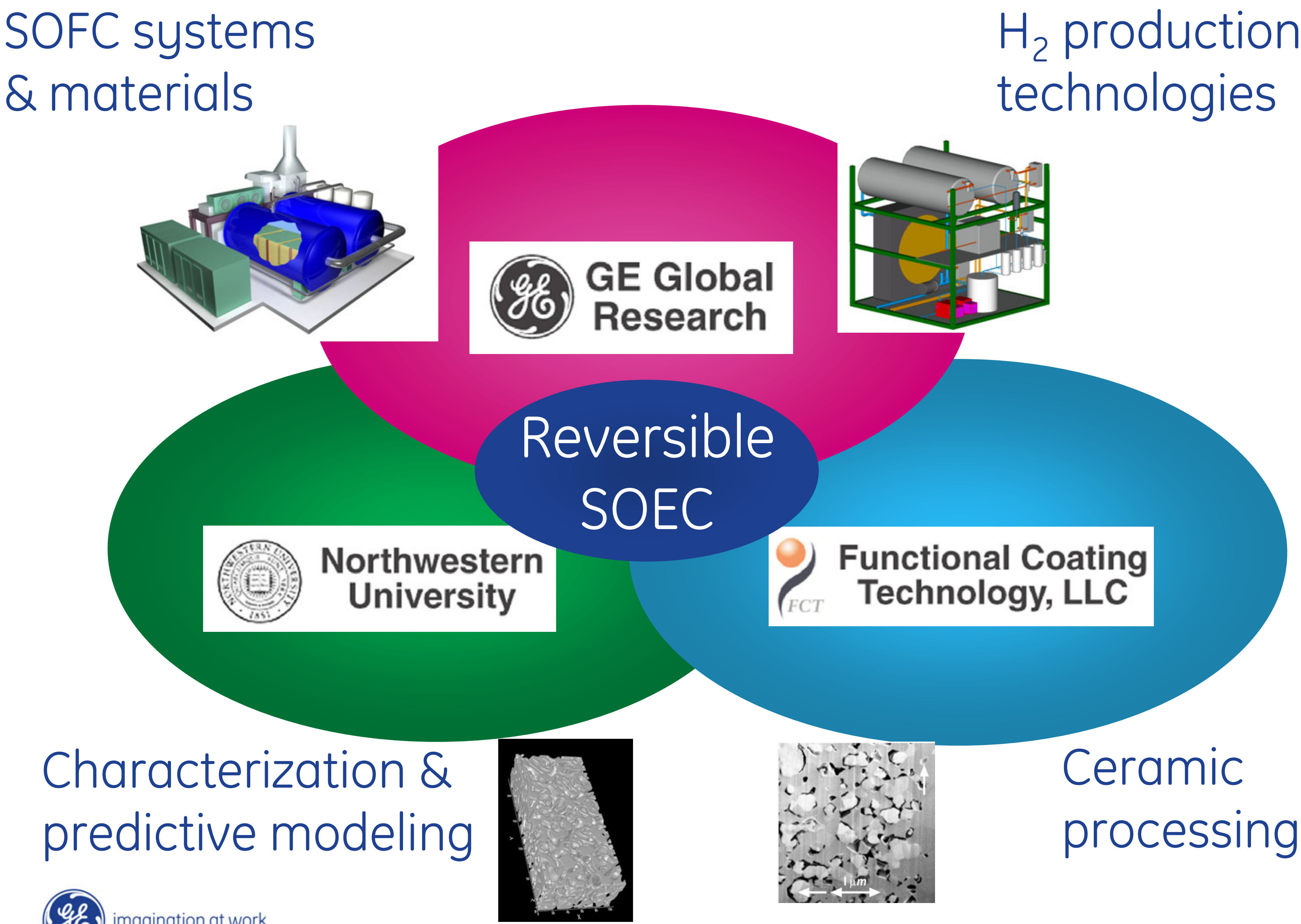

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Hydrogen Safety

The most significant hydrogen hazard associated with this project is uncontrolled combustion of a hydrogen leak with air during performance testing of SOEC button cells.

Hydrogen Safety

Our approach to deal with this hazard is:

- Design test rigs for controlled combustion of hydrogen gas at the outlet.
- Operate test rigs in a specially designed test lab with continuous exhaust and safety sensor systems that stop the flow of hydrogen in the event of an exhaust failure.
- Train operators with a standard operating procedure.
- Audit the test lab quarterly for safety.