DEVELOPING IMPROVED MATERIALS TO SUPPORT THE HYDROGEN ECONOMY

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Overview

Timeline
• Start Date: Sep 2004
• End Date: Jun 2009
• Complete

Budget
• FY04: $2.945 M
• FY05: $2.961 M
• FY06: $2.475 M
• FY08: $ .984 M
• DOE Total: $9.37 M
• Recipient Share: >$10.4 M

Barriers
• Hydrogen Delivery / Safety
  • Hydrogen Leakage & Sensors
  • Leak Detection Technology
• Hydrogen Production
  • Reformer Capital Cost - O&M Cost
• Manufacturing R&D
  • Lack of High-Volume MEA Proc.
  • Manual Stack Assembly
• Fuel Cells
  • Cost/Performance – Catalysts / MEA

Partners
• Makel Engineering - H₂ Sensor
• Precision Energy - Membrane Processing
• Catacel Corp. - Reformation
• Faraday Technology - Catalyst Application
• NexTech Materials - H₂ Sensor
• Powdermet, Inc. – H₂ Storage
• UltraCell Corp - Fuel Cell Power
Edison Materials Technology Center (EMTEC) used goals set forth in the USDOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Plan to find and fund projects which satisfied these criteria:

- Demonstrate feasibility with job creation potential
- Cross-cutting breakthrough materials technology
- Stimulate near term manufacturing-based commercialization
- Patterned on EMTEC Core/Commercial Technology (CT) model
# Target Technologies and Barriers

<table>
<thead>
<tr>
<th>Target Technology</th>
<th>DOE Barriers Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂ Generation from Renewable Liquid Feedstocks</td>
<td>Fuel Processor Capital Costs, O&amp;M Cost</td>
</tr>
<tr>
<td>H₂ Generation by Water Electrolysis</td>
<td>Renewable Integration</td>
</tr>
<tr>
<td>H₂ Generation by Photo-electrochemical Electrolysis</td>
<td>Materials Efficiency, Bulk Materials Synthesis, Device Configuration Designs</td>
</tr>
<tr>
<td>H₂ Separation Materials – Catalysts, MEA</td>
<td>Cost, Impurities</td>
</tr>
<tr>
<td>H₂ Generation from Biomass and Coal</td>
<td>Capital Cost and Efficiency</td>
</tr>
<tr>
<td>H₂ Storage by New Materials and Concepts</td>
<td>Efficiency, Cost, Weight and Volume</td>
</tr>
<tr>
<td>H₂ Processing: Sensors, Delivery, Purification</td>
<td>Hydrogen Leakage &amp; Sensors Leak Detection Technology, Durability, Cost</td>
</tr>
</tbody>
</table>
Approach

- EMTEC solicited projects that:
  - Have industry relevance
  - Are appropriately resourced
  - Are aligned with EERE Hydrogen Goals
  - Address multiple DOE Barriers
  - Have near term commercialization viability

- EMTEC has extensive experience managing collaborative technology projects

- EMTEC has an established business model for selection and management of technology commercialization projects
EMTEC

- EMTEC is one of 7 State of Ohio Edison Centers
  - Established in 1987 by Ohio Gov. Celeste
  - 501c(3) Not-for-Profit

- Membership Based with Over 120 Industry, University, and Government Members

- Virtual – We Own no Major Capital Equipment

- Access to Over $2B in State-Of-The-Art Facilities

- Significant Experience in Ceramics, Metals, Polymers, and many Material Processes - expanded focus includes Instruments, Controls, & Electronics (ICE)
EMTEC Interactions/Collaborations

- Air Force Research Laboratory
  - Technology transfer program
  - Commercialization & business development
  - SBIR & Commercialization pilot program support

- State of Ohio
  - Department of Development Technology Division
  - Third Frontier Program
    - Multiple fuel cell projects
    - Photovoltaic Innovation Center (PVIC)
  - Ohio Fuel Cell Coalition

- Business Outreach Services
  - Procurement Technical Assistance Center (PTAC)
  - International Trace Assistance Center (ITAC)

- EMTEC Membership Technical Steering Committee (TSC)
PARTNERS
Low Cost MEMS Hydrogen Sensor for Transportation Safety
Makel Engineering, Inc.

- **DOE Barriers Addressed:**
  - Control and safety
- **Total Project Value:** $736,656
- **Goals and Objectives:**
  - Advanced hydrogen sensor system for hydrogen powered transportation applications
  - Provides the means for low cost, compact, low power, and miniaturized systems suitable for mass production
- **Accomplishments:**
  - Prototype H₂ sensor developed and automotive testing initiated
  - R&D 100 Award (2006)
  - Nano 100 Award (2006)
- **Future Work:**
  - Nanomaterial enhancements, product testing with automotive partners, improved manufacturability at reduced cost, and market development

EMTEC - Accelerating Technology to Market
2006 R&D 100 Award
“Ultrafast Nanostructured Hydrogen Sensor”
DOE Barriers Addressed:
- Materials Efficiency, Bulk Materials Synthesis, Device Configuration Designs

Total Project Value: $935,386

Goals and Objectives:
- Low cost manufacture of PEM MEAs for hydrogen and/or electric generation through reel-to-reel manufacture technology

Accomplishments:
- MEA Bonder System produced.
- Demonstrated capability to continuously manufacture 3-layer MEAs
- Membranes can be used to generate hydrogen

Future Work:
- Refine catalyst utilization and manufacturing processes
PARTNERS
Novel Stackable Structural Reactor (SSR™) for Low-cost Hydrogen Production - Catacel Corp.

- **DOE Barriers Addressed:**
  - Fuel Processor Manufacturing, Operation and Maintenance, Refomer Capital Cost – O&M Cost

- **Total Project Value:** $692,737

- **Goals and Objectives:**
  - Drop-in replacement for the loose ceramic catalyst media in the stationary steam reforming process
  - Allows 50% additional capacity from given plant size, or 10% energy savings

- **Accomplishments:**
  - Lab evaluations complete, pilot manufacturing installed
  - Pilot plant install and test

- **Future Work:**
  - Market entry
DOE Barriers Addressed:
- Efficiency, Cost, Weight and Volume.

Total Project Value: $1,034,445

Goals and Objectives:
- Demonstrate technical and economic feasibility of Tunable Diode Laser Absorption Spectrometer (TDLAS) for analysis within PEM fuel cell bipolar plate channels

Accomplishments:
- Nanoscale catalysts for hydrogen generation
- Bipolar plate fabrication for PEM fuel cells with integrated sensors/shunts
- Briefed DOE

Future Work:
- Evaluate strategic partnerships for bipolar plate applications
- Product development and market evaluation

PARTNERS
DOE Barriers Addressed:
- Efficiency, Cost, Weight and Volume.

Total Project Value: $548,950

Goals and Objectives:
- Advance prototype multi-fuel SOFC system for commercialization

Accomplishments:
- Beta prototype demonstration in plant with soybean/vegetable oil based fuels

Future Work:
- Continue test of prototype system with multi-fuel sources – select candidate test site
- Improve long term cell and stack component performance
- Product development and commercialization
**DOE Barriers Addressed:**

**Total Project Value:** $794,602

**Goals and Objectives:**
- Design low-cost H₂ safety sensor that is sensitive and selective to H₂.
- Take technology from bench-top to prototype level, ready for product launch to market.

**Accomplishments:**
- Demonstrated high selectivity to hydrogen without interference from CO, CH₄, H₂O, or silicone vapors; a-prototypes have been tested with excellent performance for 2000+ hours.
- Design for manufacturing; Pilot manufacturing; Market entry

**Future Work:**
- Operational validation
DOE Barriers Addressed:
- Weight and volume, efficiency, portability

Total Project Value: $727,142

Goals and Objectives:
- High-strength microballoons by chemical vapor deposition for high volume hydrogen storage
- Store 6 wt. % H2 in balloons, >4 wt. % in system for 2mm balloons
- Collaborators include AF Research Labs, Precision Energy and Technology, and Protonex

Accomplishments:
- Verified microballoon extended duration H₂ storage and completed initial system design studies.

Future Work:
- Evaluate microballoon technology for other uses.
DOE Barriers Addressed:
- Efficiency, Cost, Weight and Volume

Total Project Value: $425,000

Goals and Objectives:
- Develop and Demonstrate technology with potential customers to accelerate next level of funding support and purchase order generation.

Accomplishments:
- Testing at “alpha” sites such as the Federal Bureau of Investigation (FBI), U.S. Forestry Service, U.S. Marine Corp, and the Air Force Research Laboratory (AFRL).
- JRTC Technology Readiness Level (TRL) 7 status
- Follow-on Ohio Third Frontier Award

Future Work:
- Secure tooling for continued long-term material evaluation.
- Field additional prototypes for feedback from Alpha sites.
- Continue performance and form factor work for manufacturing plant outlines.
PARTNERS
Other Notable Success Stories

- **Catacel Corp** - Scalable Steam Methane Reformer
  - $1M Ohio Third Frontier Program follow-on (heat exchanger)
- **Midwest OptoElectronics (MWOE)** – PV Hydrogen Generation
  - Formed into **Xunlight Corporation** - Flexible thin-film PV
    Substantial New Capital Investment
- **Praxair** – Improved Hydrogen Liquefaction Process
  - $2.1M DOE follow-on for improved ortho-para conversion process
- **Inorganic Specialists** – Nanofiber Paper for H₂ Generation
  - $2M ARPA-E Program Award – Nanofiber Paper as Lithium-Ion Anode
- **Chemsultants** – Roll-to-Roll Solution Casting for PEMs
- **Proton Energy** – High Pressure Electrolyzer for Backup Power Systems
- **Protonex** – Methanol Reformed Hydrogen for PEMs
Summary

- EMTEC manages a program with a DOE cooperative agreement in Hydrogen, Fuel Cells & Infrastructure Technologies

- Program featured 38 individual, topically-related projects
  - Phased Projects - based on success
  - 7 Active Phase III Projects

- Each project targets at least one DOE technical barrier

- Successful projects continue to generate jobs and marketable products or processes