



DEVELOPING IMPROVED MATERIALS TO SUPPORT THE HYDROGEN ECONOMY

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June 7, 2010

Project ID# PD043

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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



Program Objectives

Relevance

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

Target Technology	DOE Barriers Addressed
H ₂ Generation from Renewable Liquid Feedstocks	Fuel Processor Capital Costs, O&M Cost
H ₂ Generation by Water Electrolysis	Renewable Integration
H ₂ Generation by Photo-electrochemical Electrolysis	Materials Efficiency, Bulk Materials Synthesis, Device Configuration Designs
H ₂ Separation Materials – Catalysts, MEA	Cost, Impurities
H ₂ Generation from Biomass and Coal	Capital Cost and Efficiency
H ₂ Storage by New Materials and Concepts	Efficiency, Cost, Weight and Volume
H ₂ Processing: Sensors, Delivery, Purification	Hydrogen Leakage & Sensors Leak Detection Technology Durability, Cost

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

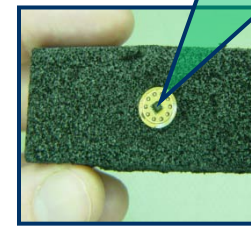
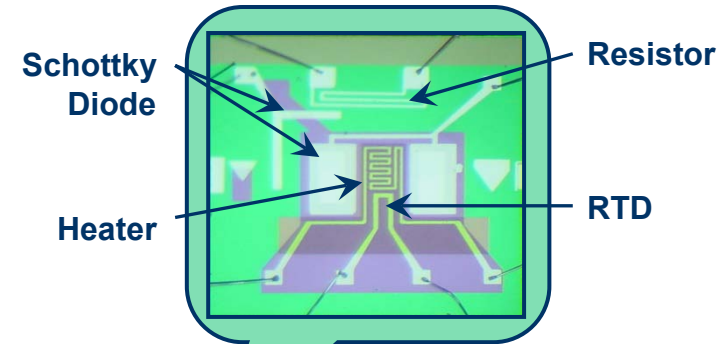
Interactions/Collaborations

- 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 Trade Assistance Center (ITAC)
- EMTEC Membership Technical Steering Committee (TSC)

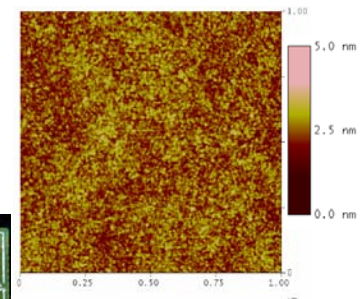
PARTNERS

Low Cost MEMS Hydrogen Sensor for Transportation Safety
Makel Engineering, Inc.

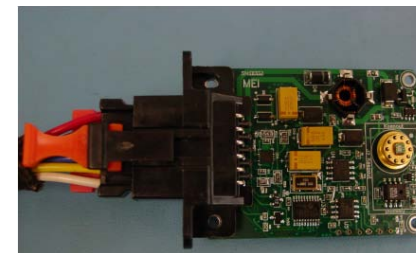
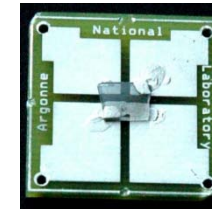
- **DOE Barriers Addressed:**
 - Control and safety
- **Total Project Value:** \$736,656
- **Goals and Objectives:**
 - Advanced hydrogen sensor system for hydrogen powered transportation applications
 - Provides the means for low cost, compact, low power, and miniaturized systems suitable for mass production
- **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



MEMS H₂ Sensor

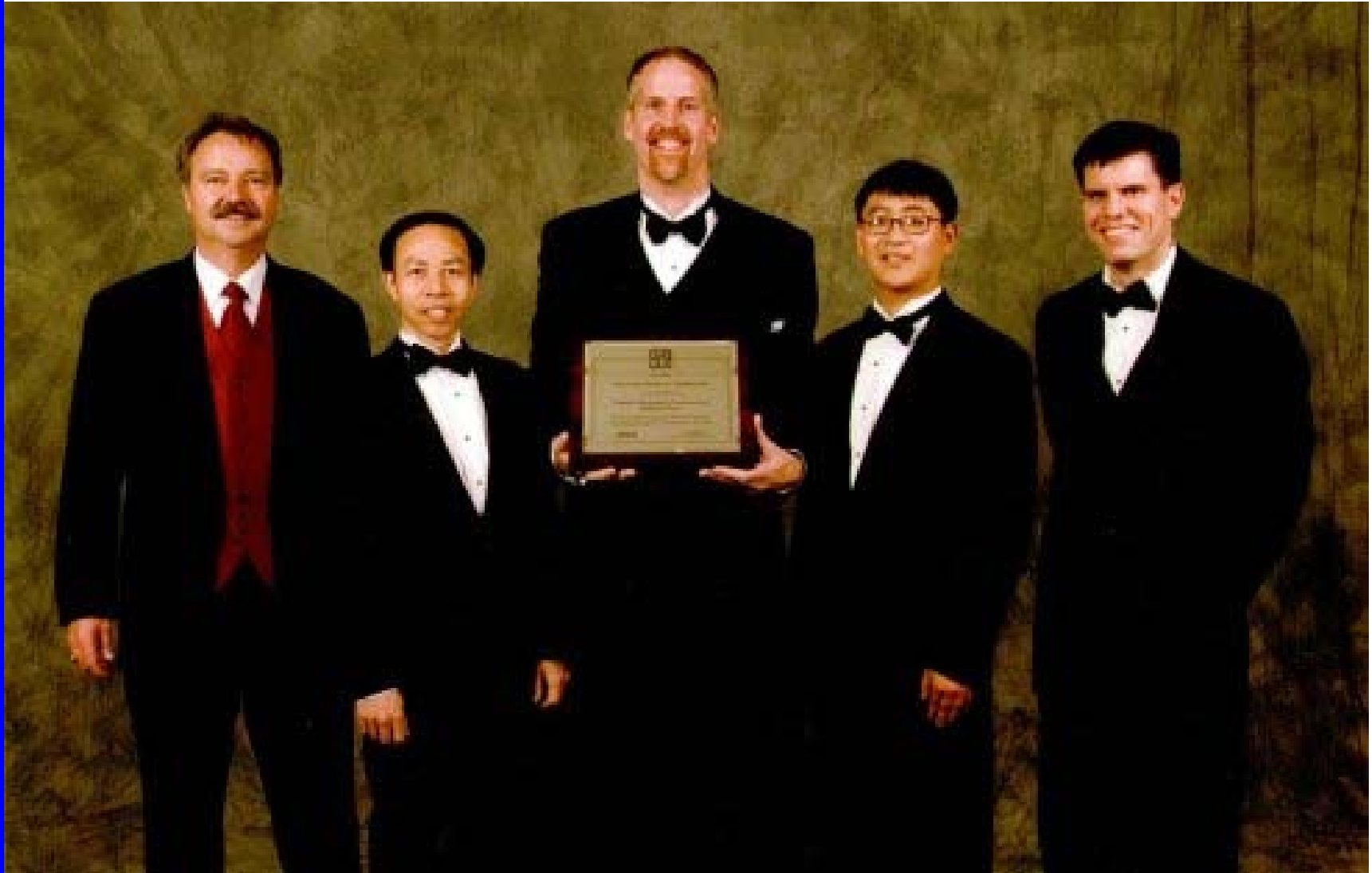


Palladium Nanocluster Sensor Film



Prototype Detector Electronics

2006 R&D 100 Award “Ultrafast Nanostructured Hydrogen Sensor”



PARTNERS

Reel-to-Reel High Volume, Low Cost MEA Production - Precision Energy & Technology

- **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, Reformer 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

PARTNERS

TDLAS Sensor for In-Line Continuous Monitoring of PEM Fuel Cells & Electrolyzers – Faraday Technology, Inc.

- **DOE Barriers Addressed:**

- Efficiency, Cost, Weight and Volume.

- **Total Project Value:** \$1,034,445

- **Goals and Objectives:**

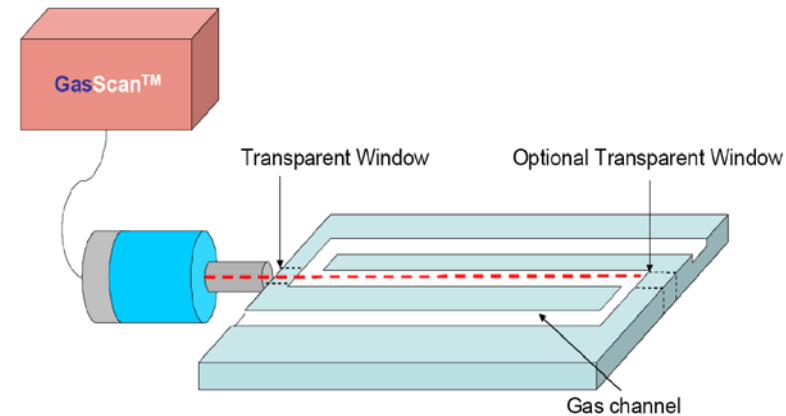
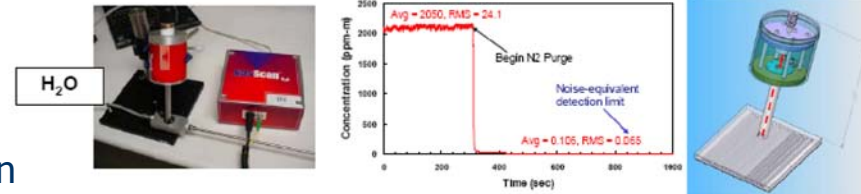
- Demonstrate technical and economic feasibility of Tunable Diode Laser Absorption Spectrometer (TDLAS) for analysis within PEM fuel cell bipolar plate channels

- **Accomplishments:**

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

- **Future Work:**

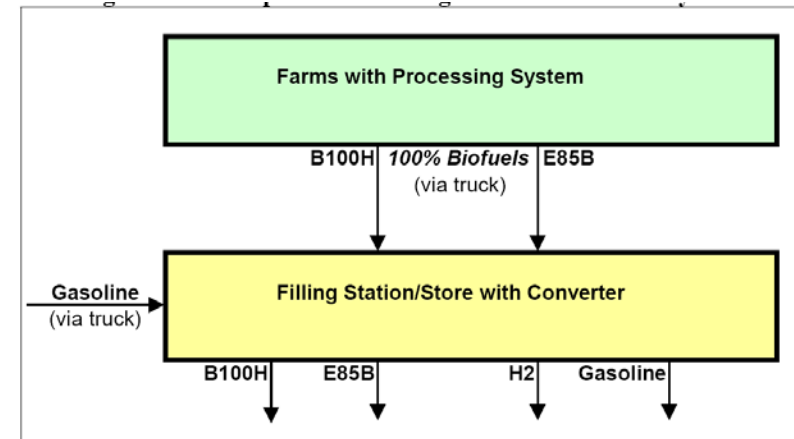
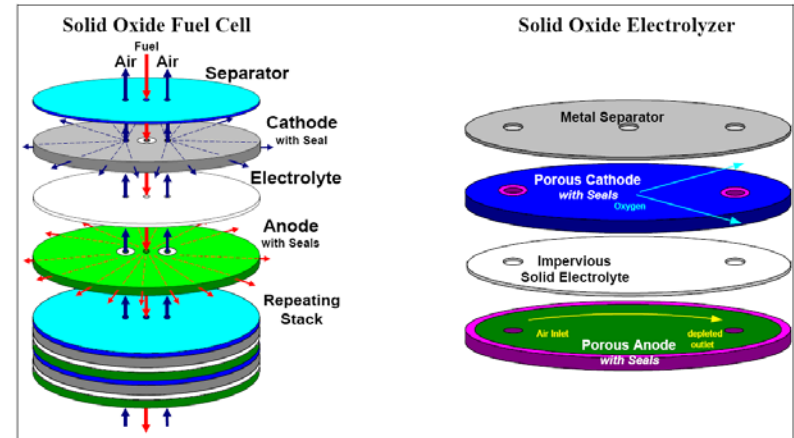
- Evaluate strategic partnerships for bipolar plate applications
- Product development and market evaluation



PARTNERS

On-Farm Soybean-Powered TMI SOFC System Demonstration – Technology Management, Inc.

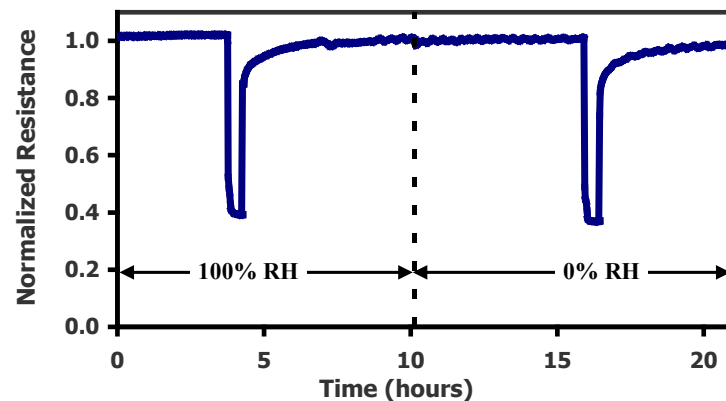
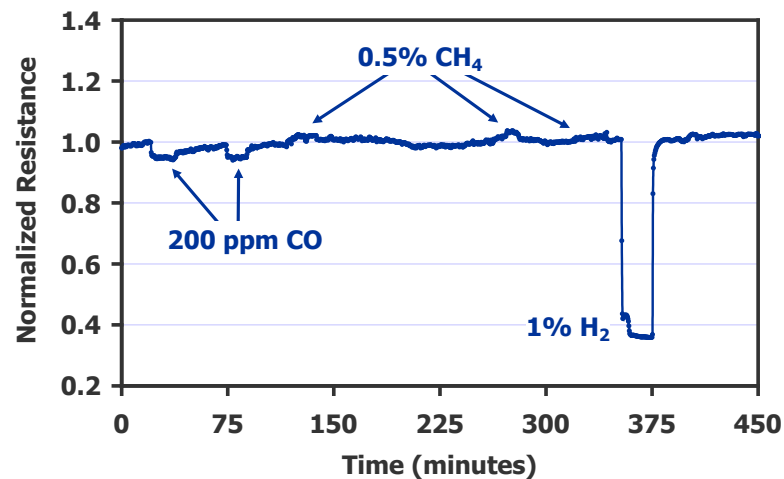
- **DOE Barriers Addressed:**
 - Efficiency, Cost, Weight and Volume.
- **Total Project Value:** \$548,950
- **Goals and Objectives:**
 - Advance prototype multi-fuel SOFC system for commercialization
- **Accomplishments:**
 - Beta prototype demonstration in plant with soybean/vegetable oil based fuels
- **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



PARTNERS

Novel Ceramic Hydrogen Sensors for Fuel Cell Applications – NexTech Materials

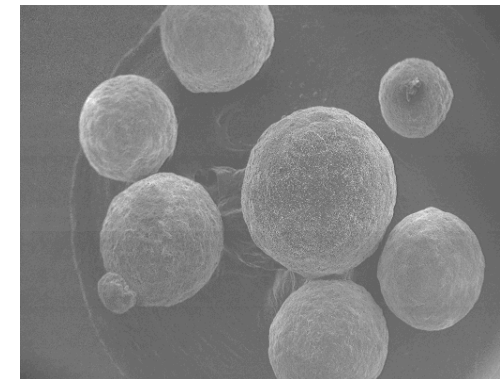
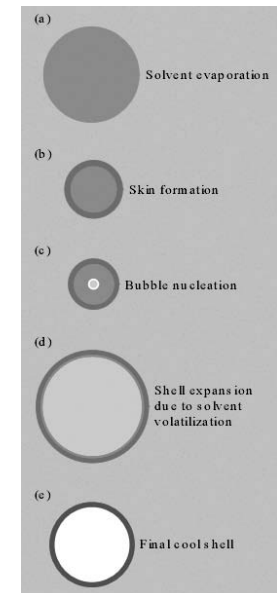
- **DOE Barriers Addressed:**
 - Hydrogen Leakage & Sensors, Leak Detection Technology, Control and Safety.
- **Total Project Value:** \$794,602
- **Goals and Objectives:**
 - Design low-cost H₂ safety sensor that is sensitive and selective to H₂.
 - Take technology from bench-top to prototype level, 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



PARTNERS

High Strength, Low-Cost Microballoons for Hydrogen Storage - Powdermet Inc.

- **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.



PARTNERS

Manufacturing UltraCell's Reformed Methanol Micro Fuel Cells in the State of Ohio For Military and Commercial Markets

- **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).
- Soldier Technology U.S. 2008 Conference: **"Best Soldier System Innovation & Technology" Award.**
- 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.



- **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