



# **DEVELOPING IMPROVED MATERIALS TO SUPPORT THE HYDROGEN ECONOMY**

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This presentation does not contain any proprietary or confidential information

# Overview

## Timeline

- Start Date: Sep 2004
- End Date: Jun 2009
- 95% Complete

## Budget

- FY04: \$2.945 M
  - FY05: \$2.961 M
  - FY06: \$2.475 M
  - FY08: \$ .984 M
- Total: \$9.365 M**
- Contractor cost share  
> \$9.6 M
  - State of Ohio cost share  
> \$3.8 M

## Barriers

- PD - Fuel Processor Capital Costs
- PD, MF - Renewable Integration
- MF, ST, AN - Materials Efficiency
- PD, ST, MF - Cost, Impurities
- PD, MF - Capital Cost & Efficiency
- AN - Efficiency, Cost, Wt. & Volume
- PD, ST, MF, AN - Durability, Cost

## Partners

- Makel Engineering - H<sub>2</sub> Sensor
- Precision Energy - Membrane Proc.
- Catacel Corp. - Reformation
- Faraday Technology - Catalyst App.
- Technology Mgmt. - Multi Fuel SOFC
- NexTech Materials - H<sub>2</sub> Sensor
- Powdermet, Inc. - H<sub>2</sub> Storage
- UltraCell Corp. - Fuel Cell Power



# Program Objectives

## Relevance

Edison Materials Technology Center (**EMTEC**) uses goals set forth in the USDOE *Hydrogen, Fuel Cells & Infrastructure Technologies Program Plan* to find and fund projects which satisfy 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 Barrier Addressed
H <sub>2</sub> Generation from Renewable Liquid Feedstocks	Fuel Processor Capital Costs
H <sub>2</sub> Generation by Water Electrolysis	Renewable Integration
H <sub>2</sub> Generation by Photo-electrochemical Electrolysis	Materials Efficiency, Bulk Materials Synthesis, Device Configuration Designs
H <sub>2</sub> Separation Materials	Cost, Impurities
H <sub>2</sub> Generation from Biomass and Coal	Capital Cost and Efficiency
H <sub>2</sub> Storage by New Materials and Concepts	Efficiency, Cost, Weight and Volume
H <sub>2</sub> Processing: Sensors, Delivery, Purification	Durability, Cost

# Approach

- EMTEC solicited projects that:
  - Have Industry Relevance
  - Are Appropriately Resourced
  - Are Aligned with EERE Hydrogen Goals
  - Address DOE Barriers
  - Have Near Term Commercialization Viability
- EMTEC has extensive experience managing collaborative technology projects
- EMTEC has developed a business model for selection and management of core/commercial technology



# 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 140 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



# EMTEC

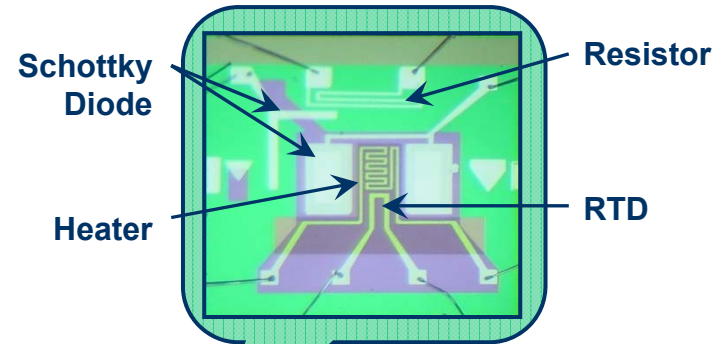
## Interactions/Collaborations

- 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 / Wright Fuel Cell Group
- Business Outreach Services
  - Procurement Technical Assistance Center (PTAC)
  - Manufacturing Small Business Development Center (MSBDC)
- EMTEC Technical Steering Committee (TSC)

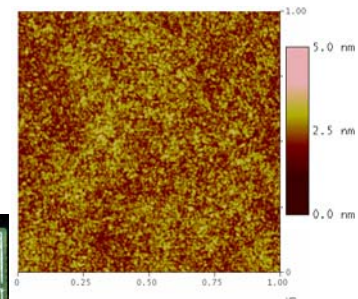
# PARTNERS

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

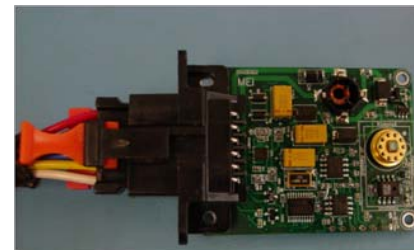
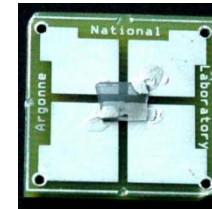
- **DOE Barriers Addressed:**
  - Control and safety
- **Total Project Value:** \$736,656
- **Goals and Objectives:**
  - Advanced hydrogen sensor system for hydrogen powered transportation applications
  - Provides the means for low cost, compact, low power, and miniaturized systems suitable for mass production
- **Accomplishments:**
  - Prototype H<sub>2</sub> sensor developed and automotive testing initiated
- **Future Work:**
  - Nanomaterial enhancements, product testing with automotive partners, improved manufacturability at reduced cost, and market development



MEMS H<sub>2</sub> Sensor



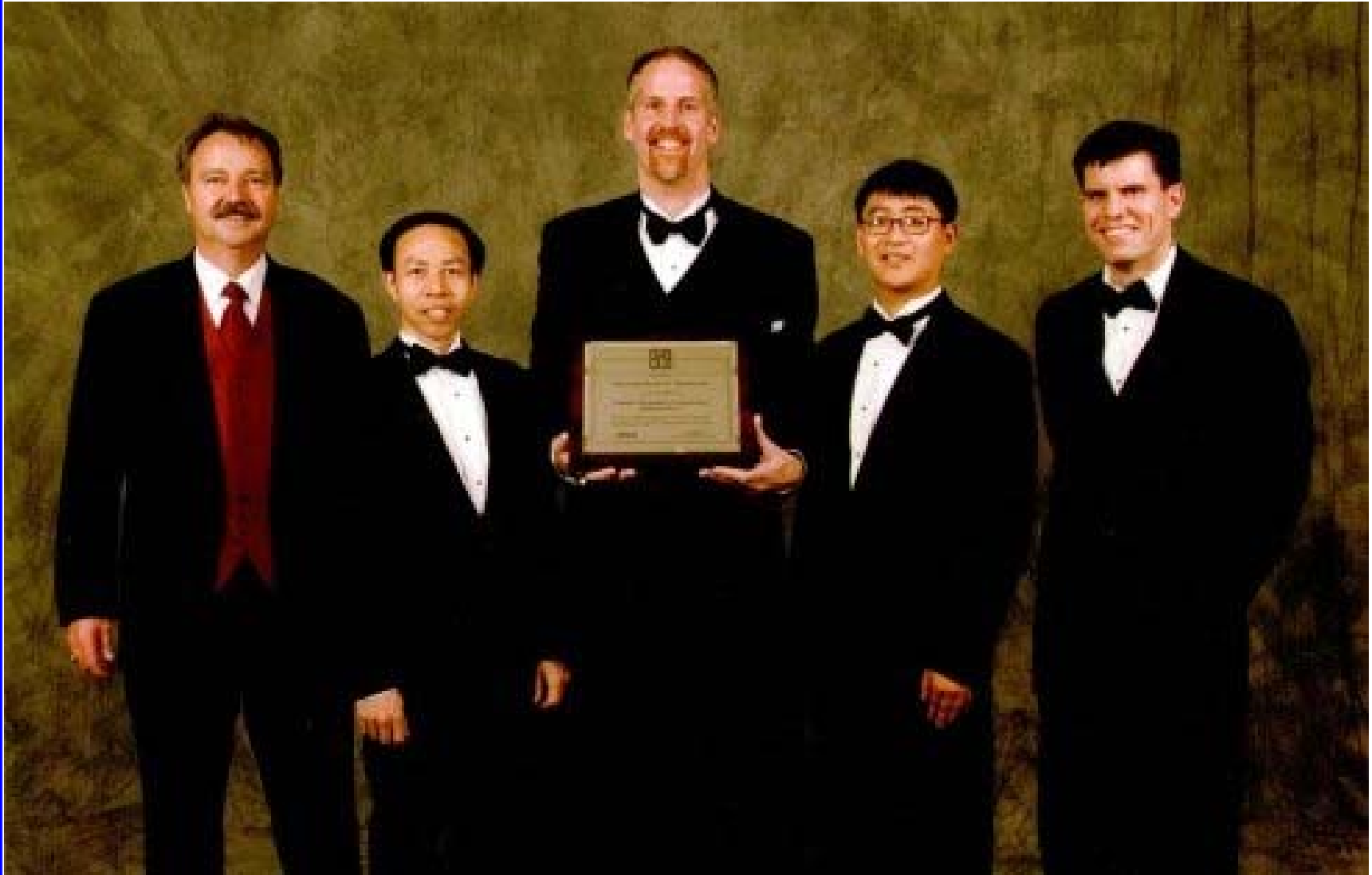
Palladium Nanocluster Sensor Film



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
- **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 evaluation complete, pilot manufacturing installed
- **Future Work:**
  - Pilot plant install & test
  - 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:**

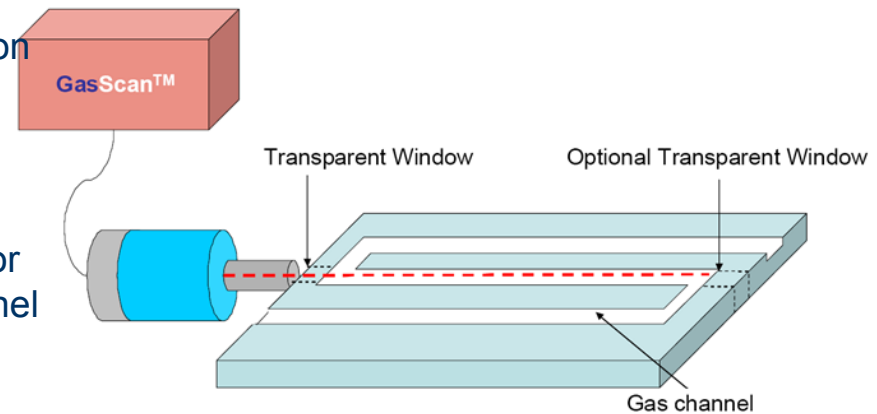
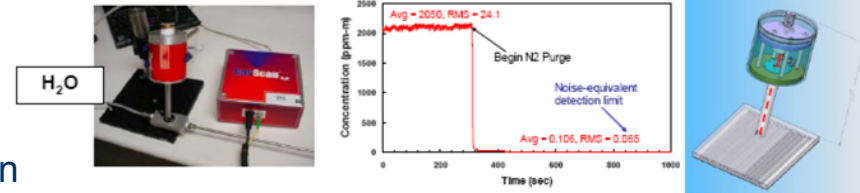
- Demonstrate technical and economic feasibility of Tunable Diode Laser Absorption Spectrometer (TDLAS) for analysis within PEM fuel cell bipolar plate channels

- **Achievements:**

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

- **Future Work:**

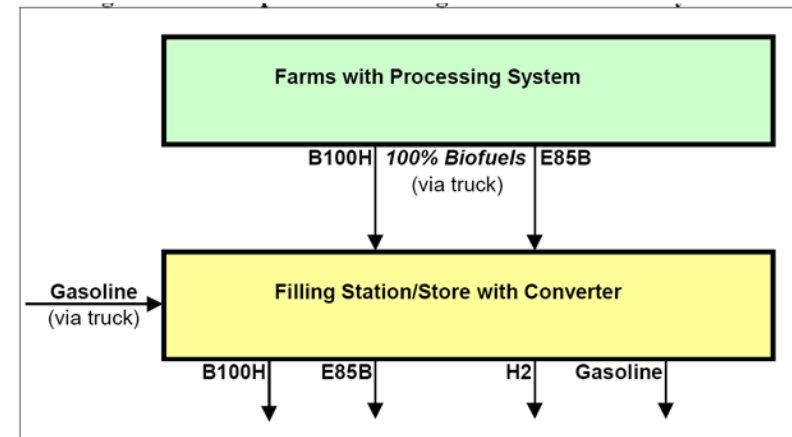
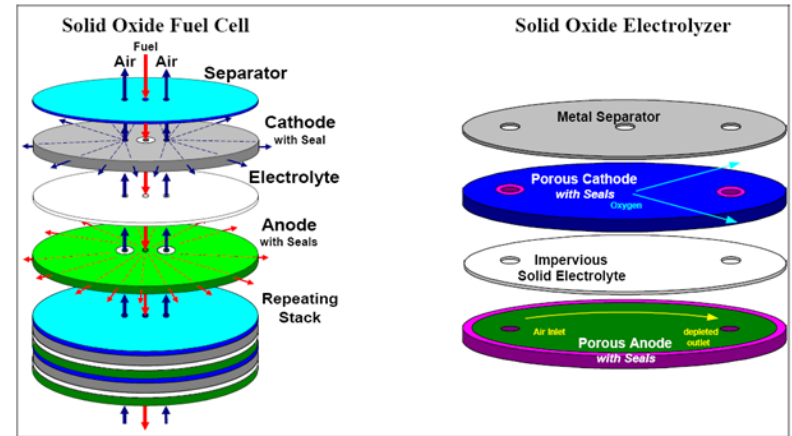
- Demonstration of the TDLAS for moisture or oxygen sensing down the length of a channel in a bipolar plate
- Design of a TDLAS capable of continuous, sequenced in-line sensing of a fuel cell or electrolyzer stack
- Product development and market evaluation



# 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
- **Achievements:**
  - 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:**

- Control and safety.

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

- **Goals and Objectives:**

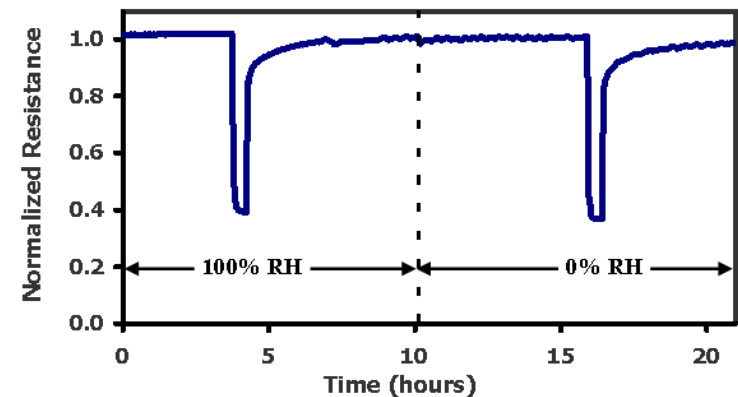
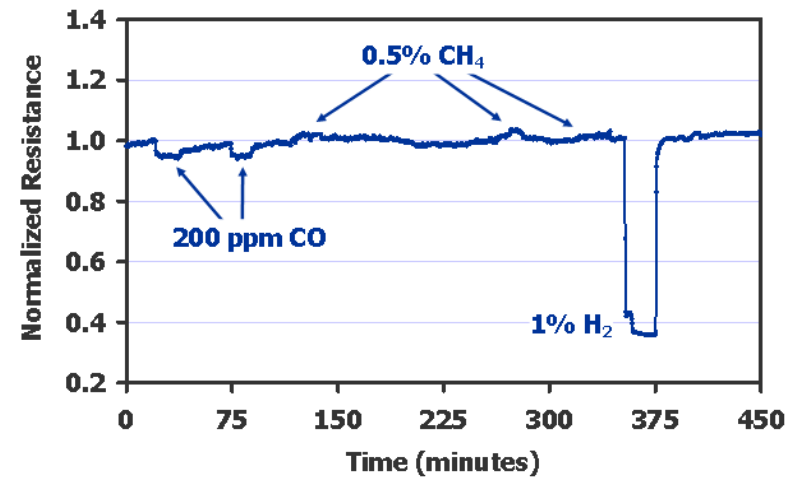
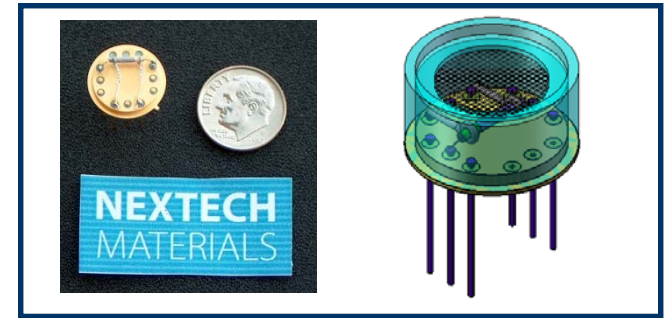
- Design low-cost H<sub>2</sub> safety sensor that is sensitive and selective to H<sub>2</sub>.
- Take technology from bench-top to prototype level, ready for product launch to market.

- **Achievements:**

- Demonstrated high selectivity to hydrogen without interference from CO, CH<sub>4</sub>, H<sub>2</sub>O, or silicone vapors; a-prototypes have been tested with excellent performance for 2000+ hours.

- **Future Work:**

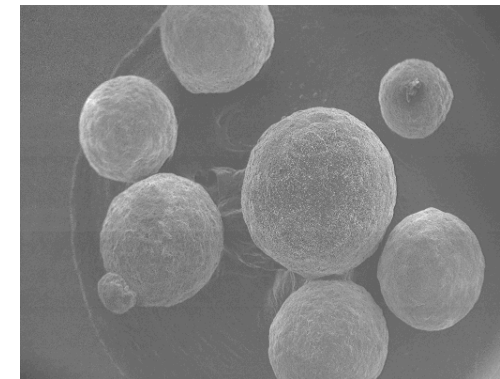
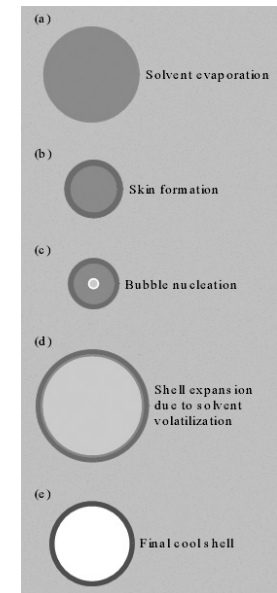
- Electronics for handling signal; Design for manufacturing; Pilot manufacturing; Production validation; market entry



## 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. % H<sub>2</sub> 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 H<sub>2</sub> storage and completed initial system design studies.
- **Future Work:**
  - Build and test prototype microballoon H<sub>2</sub> storage and delivery systems as well as 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.
- **Accomplishment:**
  - 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
- **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.





# 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 generate jobs and marketable products or processes