



DEVELOPING IMPROVED MATERIALS TO SUPPORT THE HYDROGEN ECONOMY

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This presentation does not contain any proprietary or confidential information

Objectives

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 Technology (CT) model



Target Technologies and Barriers

Target Technology	DOE Barrier Addressed
H ₂ Generation from Renewable Liquid Feedstocks	Fuel Processor Capital Costs
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	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	Durability, Cost



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 - Accelerating Technology to Market

Approach

- EMTEC solicited projects that:
 - Have Industry Relevance
 - Are Appropriately Resourced
 - Are Aligned with EE&RE 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 technology

Status and Budget

Status

- 3 RFP Rounds
- 120 White Papers and Proposals Reviewed
- 46 Site Visits Performed
- 33 Total Projects Funded

Budget

- FY04: \$2.945 Million
- FY05: \$2.961 Million
- FY06: \$2.475 Million
- Contractor cost share > \$7 million
- State of Ohio cost share: > \$2.15 million



EMTEC

Interactions/Collaborations

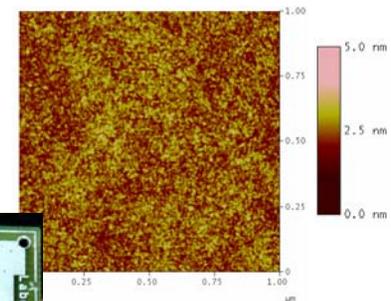
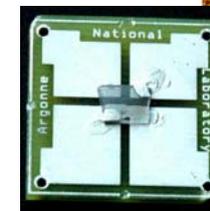
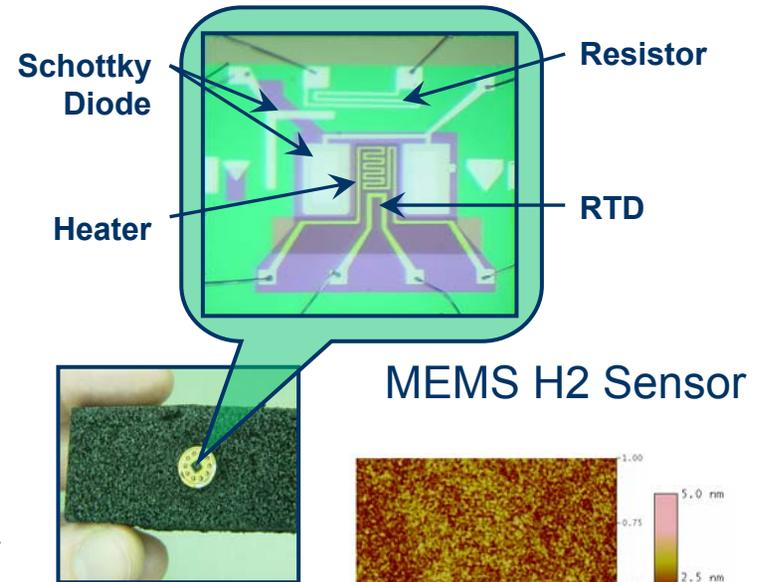
- Air Force Research Laboratory
 - Technology transfer program
 - Commercialization & business development
 - SBIR & Commercialization pilot program support
- State of Ohio
 - Department of Development Technology Division
 - Third Frontier Program
 - Multiple fuel cell projects
 - Photovoltaic Innovation Center (PVIC)
 - Wright Fuel Cell Group
- Business Outreach Services
 - Procurement Technical Assistance Center (PTAC)
 - Manufacturing Small Business Development Center (MSBDC)
- EMTEC Technical Steering Committee (TSC)

Novel Stackable Structural Reactor (SSR™) for Low-cost Hydrogen Production - Catacel Corp.

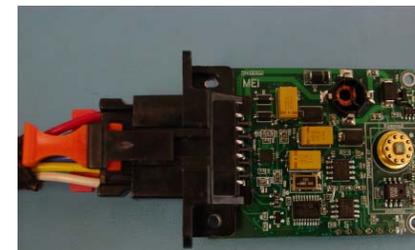


- DOE Barriers Addressed: Fuel Processor Manufacturing, Operation and Maintenance
- Total project value: \$518,737
- Drop-in replacement for the loose ceramic catalyst media in the stationary steam reforming process
- Allows 50% additional capacity from given plant size, or 10% energy savings
- Accomplishment: Lab evaluation complete, pilot manufacturing installed
- Future Work: Pilot plant installation late 2007

- DOE Barriers Addressed: Control and safety
- Total project value: \$562,656
- 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
- Future Work: Nanomaterial enhancements, product testing with automotive partners, improved manufacturability at reduced cost, and market development

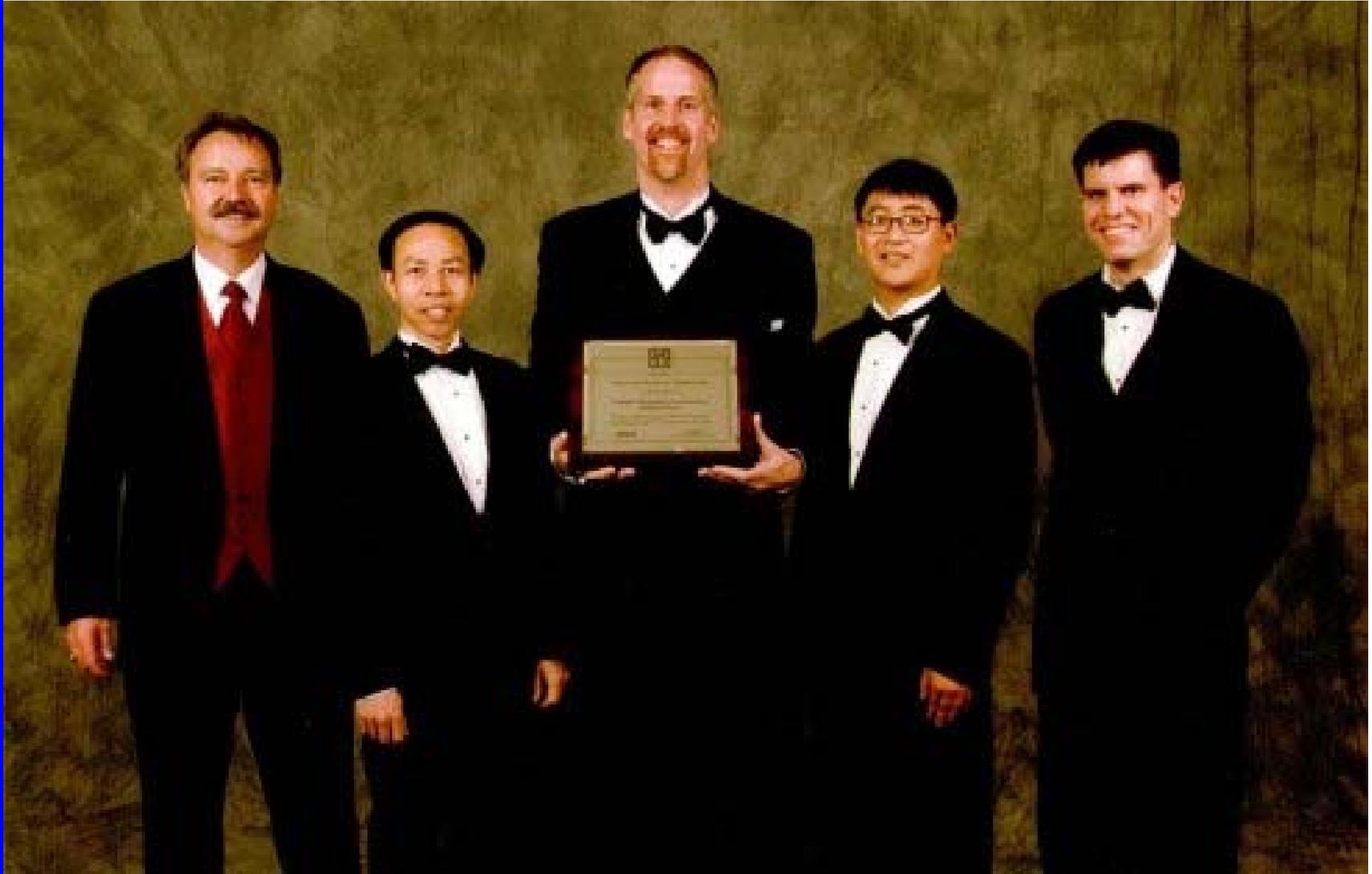


Palladium Nanocluster
Sensor Film



Prototype
Detector
Electronics

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



Development of Improved Materials for Integrated Photovoltaic - Electrolysis Hydrogen Generation Systems - MWOE

- DOE Barriers Addressed: Renewable integration, system efficiency
- Total project value: \$674,875
- Small scale manufacturing process for Integrated Photovoltaic Electrolysis (IPE) panel
 - This technology produces hydrogen from water using sunlight
- Accomplishments:
 - Technology transfer from R&D to production
 - Full size integrated photovoltaic electrolysis(IPE) panel with H₂ generation rate 100cc/min (some had ~120cc/min)
 - Mini-production completed
 - Have been under outdoor testing for 16 months and on-going
 - Completed commercialization plan
 - Significant progress in marketing and business development
 - Several new patents filed to protect MWOE solar hydrogen technologies
- Collaborators on project include the University of Toledo, Energy Photovoltaic, Inc, and National Renewable Energy Laboratory

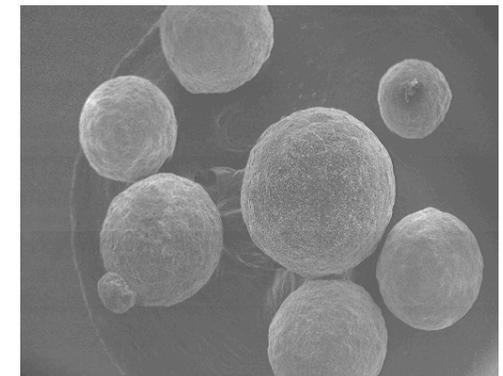
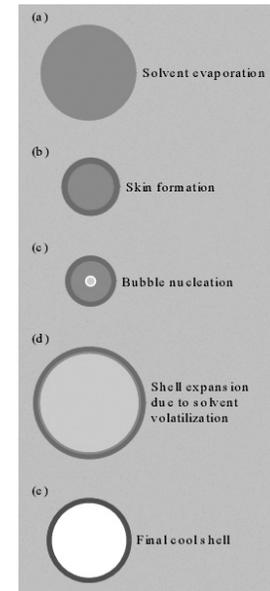


Above: Outdoor testing of the IPE panels, 16 months so far



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

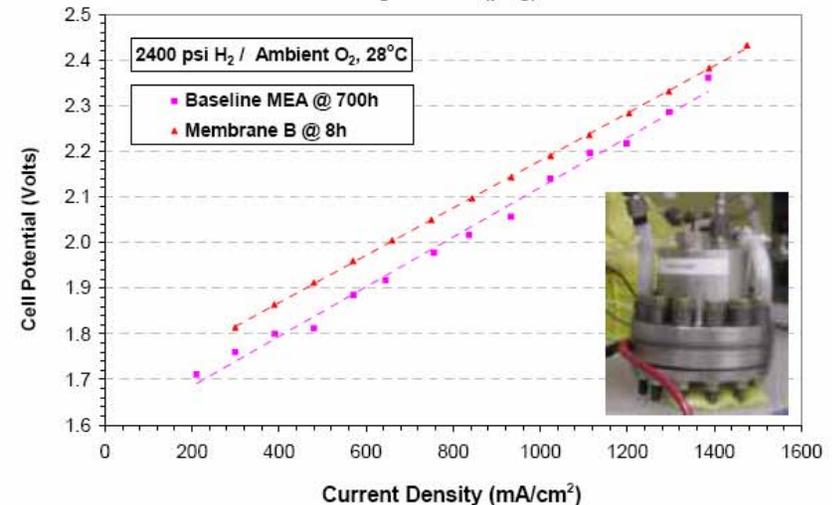
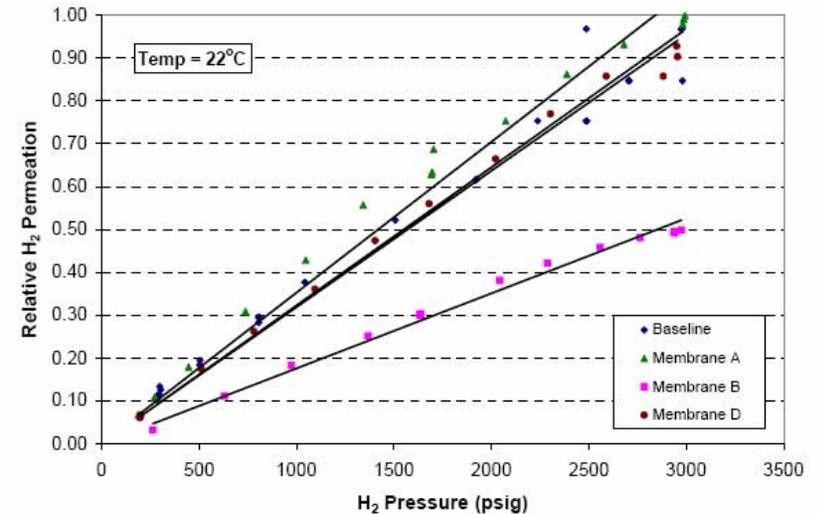
- DOE Barriers Addressed: Weight and volume, efficiency, portability
- Total project value: \$553,142
- High-strength microballoons by chemical vapor deposition for high volume hydrogen storage
 - Store 6 wt. % H₂ in balloons, >4 wt. % in system
 - Collaborators include AF Research Labs, Precision Energy and Technology, and Protonex
- Achievement: Verified microballoon H₂ storage
- Future Work: Design, build and test H₂ storage and delivery systems



Development of High Pressure Electrolyzers for Back Up Power Systems

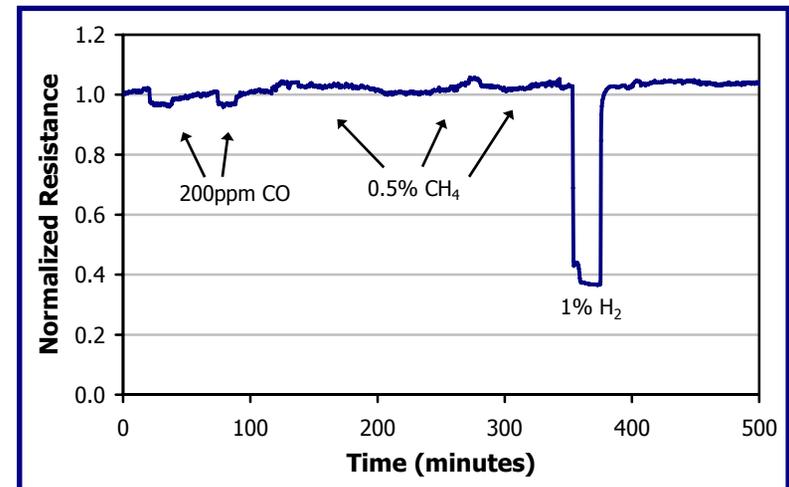
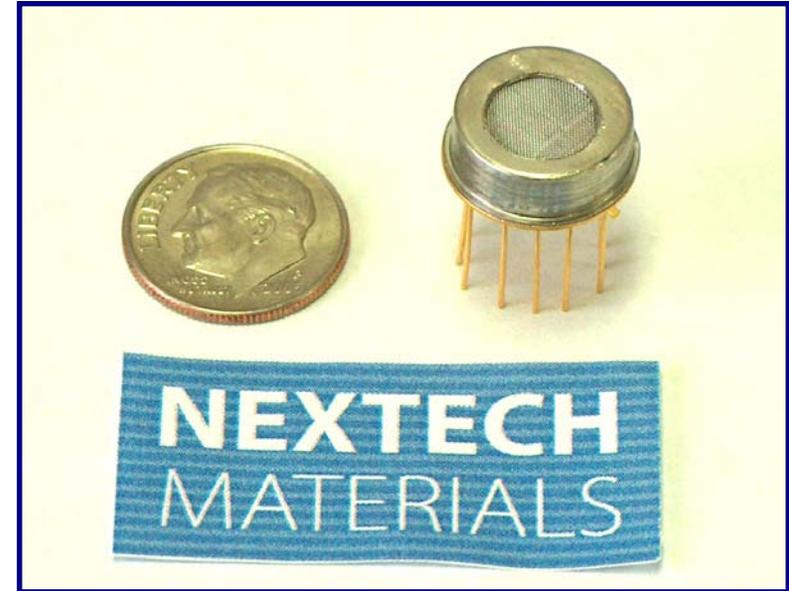
Proton Energy Systems, Inc. Wallingford, CT

- DOE Barriers Addressed:
 - G. H₂O Electrolysis System Capital Costs
 - H. H₂O Electrolysis System Efficiency
- Project Amount: \$207,526
- Goals and Objectives:
 - Identify Low Cost Electrolyzer Membrane for High (>2,000 psig) Pressure H₂ Generation Application
- Achievement:
 - Evaluated 9 candidate membranes
 - Identified promising membranes with:
 - Chemical stability
 - >50% reduction in H₂ permeation
 - Fabricated/Tested MEAs for >300 hr
- Future Work:
 - Long Term Validation
 - Scale-up



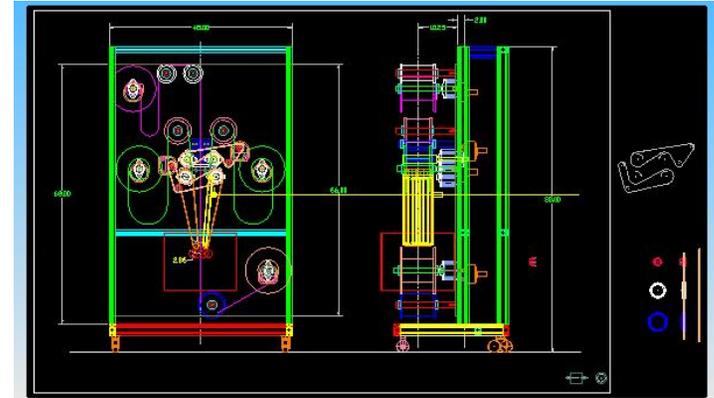
Novel Ceramic Hydrogen Sensors for Fuel Cell Applications – NexTech Materials

- **DOE Barriers Addressed:** Control and safety.
- **Total Project Value:** \$620,602
- **Goals and Objectives:**
 - Design low-cost hydrogen safety sensor that is highly sensitive and selective to hydrogen.
 - Take technology from bench-top to prototype level, ready for product launch to market.
- **Achievement:** Demonstrated high selectivity to hydrogen without interference from CO, CH₄, H₂O, or silicone vapors; α -prototypes have been tested with excellent performance for 2000+ hours.
- **Future Work:** Launch of fully packaged beta-prototypes integrated on PCB followed by field testing.



Reel-to-Reel Electrolyzer MEA Processing – Precision Energy & Technology

- DOE Barriers Addressed: Fuel processor manufacturing
- Total project value: \$216,897
- Develop continuous reel-to-reel manufacturing equipment and control processes to bring lower cost commercialization for hydrogen producing membranes
- Thermal, pressure and speed control for catalyst application and MEA bonding
- Accomplishment: Advanced reel-to-reel electrolyzer manufacturing process developed (2 Patents Applied)
- Future Work: Submit Phase II Proposal for equipment and process optimization and testing; produce hydrogen producing MEAs



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

Project Total: \$425,000 – On Budget

Project Tasks:

- 1) Complete drawings and specifications for parts and services for micro fuel cell – 85% plus completed.
- 2) Develop potential supplier list with EMTEC – 60 suppliers contacted, 10 in qualification process, over \$110k in orders placed Q1, 2007.
- 3) Contact and pre-qualify suppliers – see above.
- 4) Send RFQ and drawings – see above and in process.
- 5) Narrow supplier list – Qualification process being developed.
- 5) Order limited production parts – see above and in process.



Future Work: Continue developing our supply chain for fuel processor, cell stack and engine block.

Summary

- EMTEC manages a program with a DOE cooperative agreement in Hydrogen, Fuel Cells & Infrastructure Technologies
- Program features 33 individual, topically-related projects
- Each project targets at least one DOE technical barrier
- Successful projects generate jobs and marketable products or processes

Future Plans

- Identify and fund seven capstone projects for phase III commercialization.
 - Ultrafast nano sensors
 - Reel-to-reel membrane processing
 - High efficiency catalytic reformation
 - High utilization catalyst dispersion
 - Integrated multi-fuel SOFC
 - Highly selective hydrogen and sulfur sensor
 - Ultrahigh-strength microballoons