

HARC

**Moving knowledge to action
to improve human well-being
and
protect the environment**



HARC Clean Energy Programs



Southwest Biofuels Initiative
www.harc.edu/biofuels



Gulf Coast CHP Application Center
www.gulfcoastchp.org



Center for Fuel Cell Research & Applications
www.harc.edu/fuelcells

Center for Fuel Cell Research and Applications



- Supports commercialization of fuel cells and hydrogen technologies
- Provides technical information
- Audience: early adopters, investors, system integrators, equipment users, and component suppliers
- Supports strategic decision making by industry leaders regarding technologies and systems of the emerging hydrogen economy.
- In 2006, HARC is offering joint industry programs focused on fuel cell and hydrogen technology programs

CFCRA 2006 Core Program



- Information and intelligence on fuel cell products, companies, and emerging technologies and trends
 - **Monthly Newsletter**
 - **Quick Briefs**
 - **Technical Reports**
 - **Fuel Cell Industry Assessment Report**
 - **Sponsors Meeting**
 - **Supplemental Projects**

CFCRA 2006 Supplemental Programs



- PEM Fuel Cell UPS Test and Evaluation
 - APC InfraStruXure™ (10 kW)
 - IdaTech ElectraGen™ (5 kW)
- Portable Fuel Cell System Test and Evaluation
 - NanoDynamics Revolution™ 50
 - Voller Energy 100 v3
 - Smart Fuel Cell A50
- Distributed Hydrogen Production Equipment Test and Evaluation
 - Proton Energy Systems HOGEN
 - Teledyne Energy Systems
 - TITAN HM
 - H2Gen HGM-2000
- Plug-In Hybrid Vehicle Technology Survey

Other Activities



- Renewable energy industry leadership (TREIA)
- Tribal energy & utility development
- Green buildings
- “Cool Houston” (heat island)
- Breath of Life and Texas Interfaith Power & Light
- Green-e Certification for green power
- Environmental toxicity (genomic assay), including toxicity of carbon nanoparticles

CFCRA PEM Fuel Cell Experience



- Rapid evolution – “fruit flies of the DG sector”
- Remarkable improvement in recent years
 - Cost (now ~ \$3,000 kW)
 - Reliability
 - Size
 - Simplicity
- Convergence on niche markets
- Industry “shake-out” leaves established players

PEM Fuel Cell Market Opportunity



- PEM fuel cells emerging as Uninterruptible Power Supplies (at various scales)
- Incumbent technology at < 10 kW = Batteries
- PEMFC offers:
 - Higher power density (kW/m³)
 - Lower gravimetric power density (kW/kg)
 - Lower maintenance
 - More uniform power curve
 - Better environmental footprint

PEM Fuel Cell Commercialization Issues



- Reliability
- Cost
- Efficiency
- Fuel storage
- Operating life (MTBF)
- Fuel quality sensitivity

Fuel Cell Challenges - Catalysts



- Catalysts
 - Anode – Ionization
 - Cathode – Reduction
- Platinum Group Metals
 - High activity, high cost
- Alternative catalysts
 - Lower cost, easy contamination
- Temperature
 - Helps desorb impurities, degrades efficiency

Fuel Cell Challenges - Hydrogen



- “Energy carrier”
- Expensive
- Storage difficult
- Handling difficult
- Low density
- Purity critical
- Methanol – Fairly reactive (no C-C bonds), liquid easier to handle, but current catalysts require vapor so heating is required

Fuel Cell Challenges - Electrolyte



- Liquid
 - Hot
 - Electrode corrosion
 - Engineering/manufacturing
- Solid (e.g. Nafion)
 - Expensive
 - Degrades due to dehydration
 - Material quality
 - Non-uniform porosity
 - Binding & release sites not uniformly exposed
- Crystal – “solid oxide”
 - Heat
 - Engineering/manufacturing

Opportunities for Nanotechnology in Fuel Cell Commercialization



See: http://www.foresight.org/impact/whitepaper_illos_rev3.PDF

- Surface area
- Shelf life
- Manufacturing Cost
- Miniaturization
- Membranes – structure & efficiency
- Molecularly tailored catalysts
- Materials strength
- Solid electrolytes

Opportunities Summary



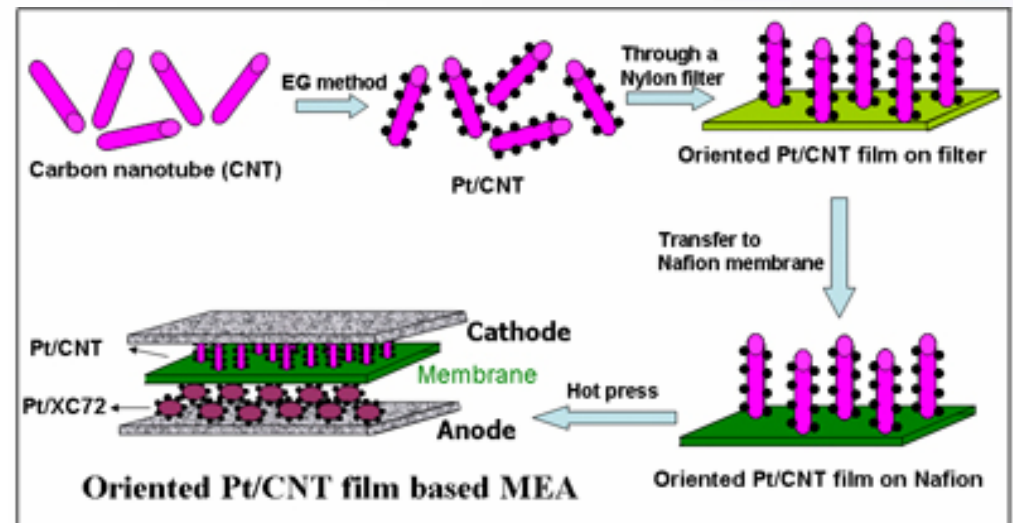
- Catalysis – “multiplier effect”
- Strength
 - Reduce mass (e.g. pays off in transportation)
 - Microscopic strength (membranes, electrolytes, bipolar plates)
- Fuel tolerance
- Passive energy handling (heat rejection & exchange)

- Photocatalysis – direct solar (+ water) to hydrogen generation cells – Altair Nanotechnology, Inc.

Example: Pacific Fuel Cell



- www.pfce.net
- Oriented carbon nanotubes in MEA in lieu of carbon black; claims:
 - Better catalyst availability
 - Lower catalyst cost
 - Longer life



Houston Advanced Research Center



The Woodlands, Texas
www.harc.edu

Thanks!

krabago@harc.edu