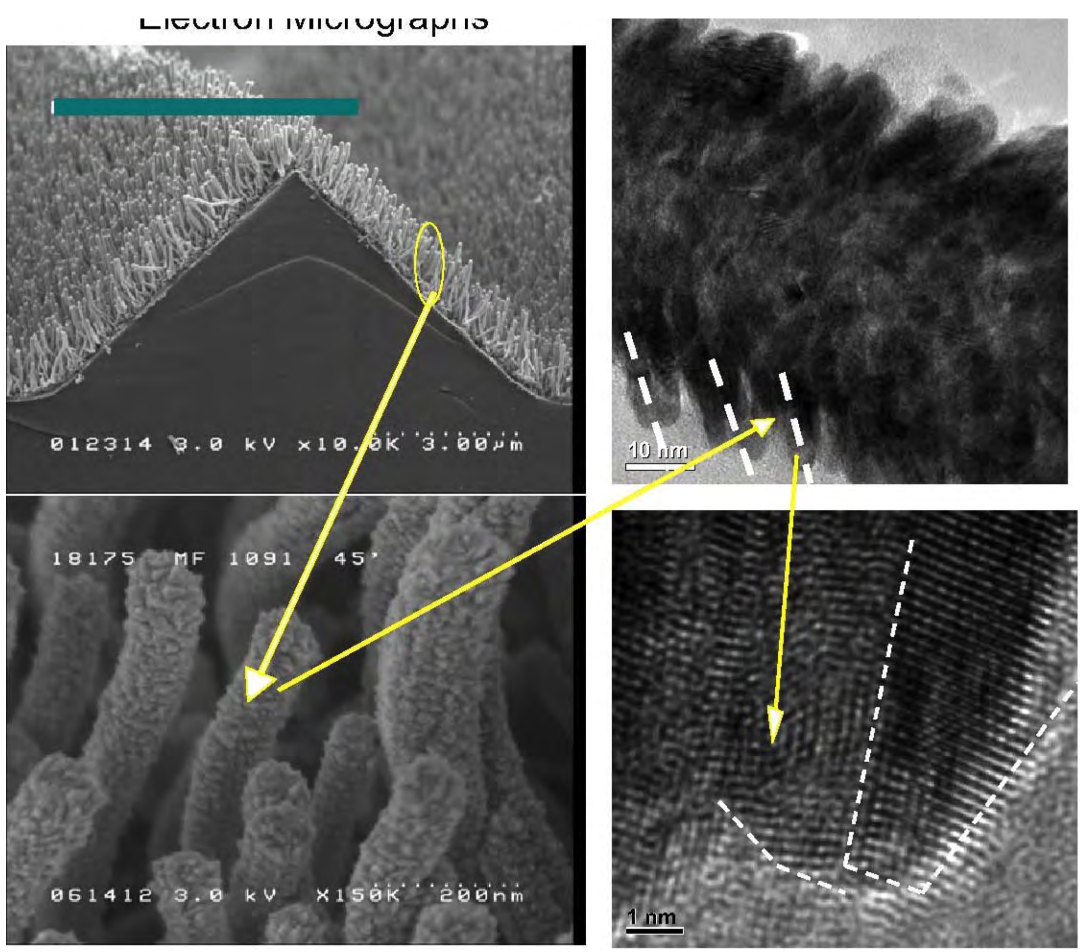
Electrocatalysis
Breakout Session



NSF-MEXT Meeting on Fuel Cells and Related Technologies

Electrocatalysis
Breakout Session

Broad Objectives [Mission Statement]

Laying the Foundation for Collaborative Research

– Identification of Active Sites and Correlation with Activity, Degradation, Ensemble Effects

– Expansion to Alternative Application and Materials Consideration

– In situ Probes and Methods [Surface and bulk] {Nano-Characterization}

– Fostering Student Exchange and Sharing of Protocols {Idea is to Broaden the Educational and Research Experience}

– Nano-engineered Materials and Interfaces to Conventional and Non Conventional Application.

Broad Challenges

- Discrete Manipulation of Surface Electronic and Geometric Properties at a Nano-Scale with Structure, Size and Material Choices in Light of Specific Bond Making and Breaking Steps
  - Active Site Manipulation at a Nano-scale
  - Understanding Electrocatalytic Pathways In Situ
  - Transport Measurements at the Nano-Scale Interface
  - Evolution of Nano-Structures under Operating Conditions
  - Time Resolved Measurements

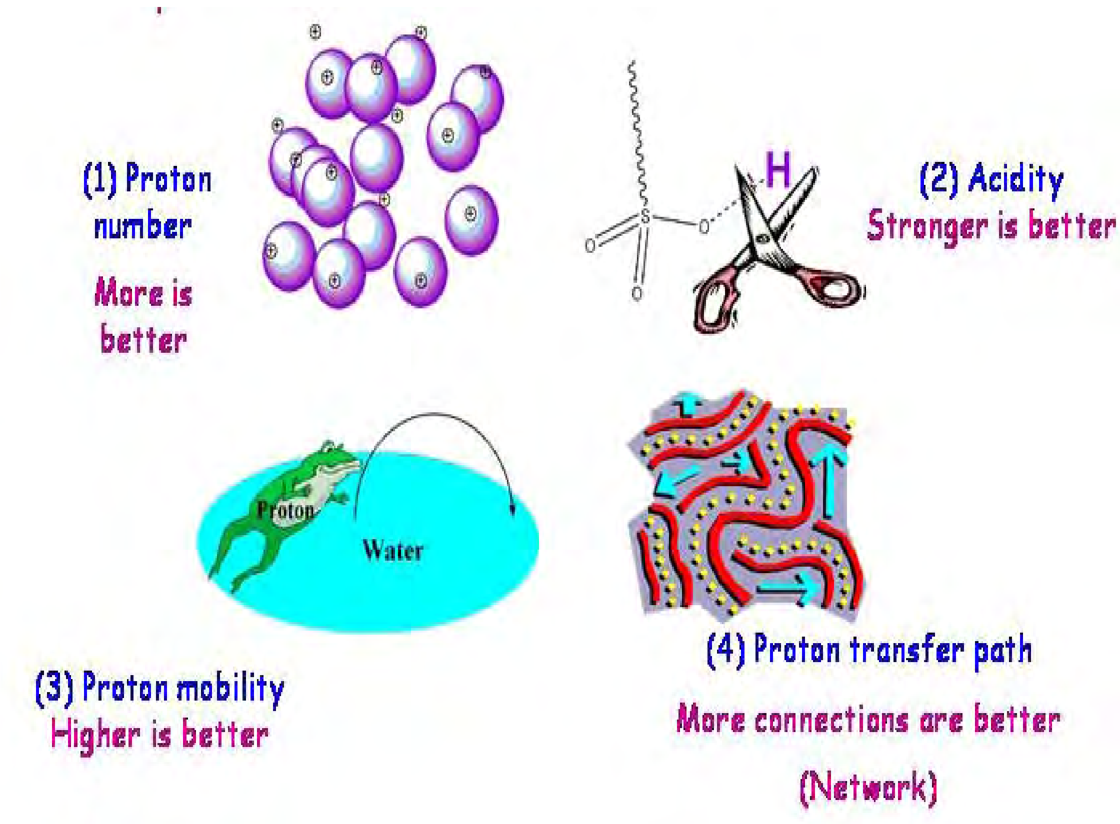
Broad Future Challenges

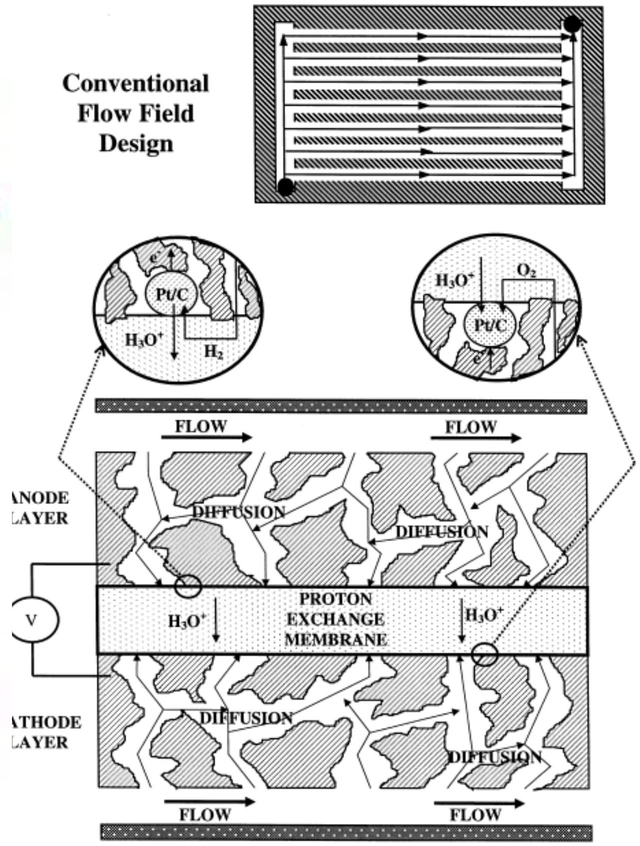
- Photo-Electrocatalysis
- Electro-Osmosis
- Lower Carbon Footprint Technologies
- Electrolysis-Hydrogen Generation
- Sensors
- New Fuel Cells
  - Bio-Fuel Cells
  - Alternative Electrolytes and Membranes

Recommendations for Future Funding

- Non-Precious Metal based Electrocatalysts for PEM Fuel Cells
- Improved Interfacial Design to Incorporate Novel Membranes and Catalysts Surfaces
- Lowering Noble Metal Loading
- Direct Oxidation of Complex Fuels
- Understanding Degradation Pathways
- Understanding Interfacial Interactions

Membrane and MEA Breakout Session





Membrane and MEA Breakout Session

Broad Objectives [Mission Statement]

Laying the Foundation for Collaborative Research

- Understanding of the nano-scale morphology of high performance PFSAs and its relations to conduction and other transport properties
- Optimize MEAs for performance and cost
- Understand and resolve issues hindering durability
- Expansion to Alternative Application and Materials Consideration
- In situ Probes and Methods [Surface and bulk] {Nano-Characterization}
- Fostering Student Exchange and Sharing of Protocols {Idea is to Broaden the Educational and Research Experience}
- Nano-engineered Materials and Interfaces to Conventional and Non Conventional Application.

Broad Challenges

- Improve membrane function at low RH (low water content)--necessary Elements
  - Fundamental understanding: Theory, new interpretation tools for structure methods, extensive measurements of properties
  - Continued emphasis on rationally driven Synthesis and Processing
  - Mechanistic understanding of proton transfer in wet and dry systems

Broad Challenges

- Improve membrane function at low RH (low water content)
  - Develop means of controlling morphological aspects of polymers at molecular to meso-scale; examples of control elements include side-chain distribution and interaction as well as polymer cluster or channel formation and their connectivity.
    - Structure development in hydrocarbon vs. PFSA
  - Assist water retention and utilization via control of nano-structure of materials
    - Complex chemical interactions in composite media need study
    - Develop inorganic/organic nano-composites or polymer blends in which nanoscale interactions improve the contribution of limited water
  - Develop ‘water-free’ conductors that are still compatible with water

Broad Challenges

- Improved MEA's
  - Compatibility between new, non-pfsa polymers and catalyst layers
  - Develop improved, multi-scale theory of composite layers
  - Low RH effects on MEA performance
  - Control nano- and meso-scale catalyst layer structure
- GDL
  - Nano-capillary regimes
    - Wettability of poorly defined, irregular materials
  - Lifetime changes in GDL
    - Loss of hydrophobicity

Broad Future Challenges

- Medium Temperature (>200^{o}C)
  - New membrane materials
    - Inorganic Materials, PBI-PA
    - Alkaline membranes or liquid electrolytes
    - Significant problems related to optimizing catalyst Layer
    - We need a breakthrough in understanding of broader classes of solid state proton conduction.
- Electrolyzers: Issues with running the fuel cell backwards
  - New MEA Materials
    - More stable supports, membranes, bipolar plates
    - Substantial catalysis issues
  - Needt to 'disseminate' PEM advances to other Electrochemical Engineering Disciplines

Broad Future Challenges

- Durability
  - Continued study of mechanisms
    - Detailed chemical studies incl. thermodynamics vs. kinetics
    - Chain scission
  - Increased emphasis on durability of hydrocarbon materials
    - Elucidation of alternative reaction paths
  - Detailed evaluation of mitigation strategies
  - MEA durability
    - Evolution of catalyst-ionomer interface (nano-scale)
    - Membrane-CL interface: Adhesion and nano-structures to promote it
  - Structural/morpholgical durability
  - Control nano- and meso-scale catalyst layer structure

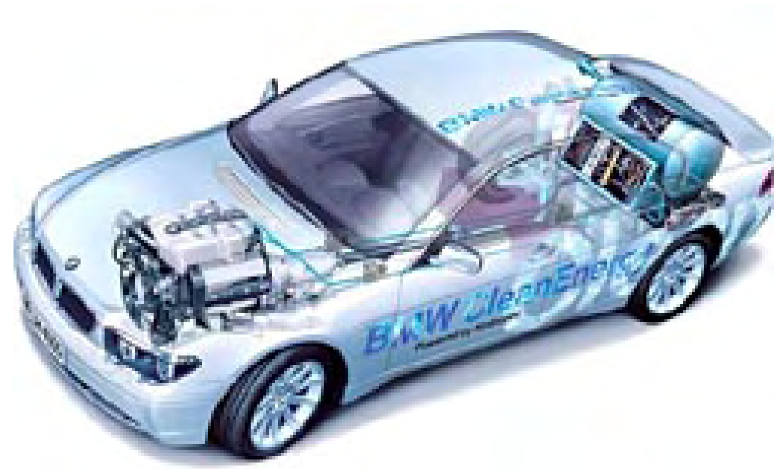
Broad Future Challenges

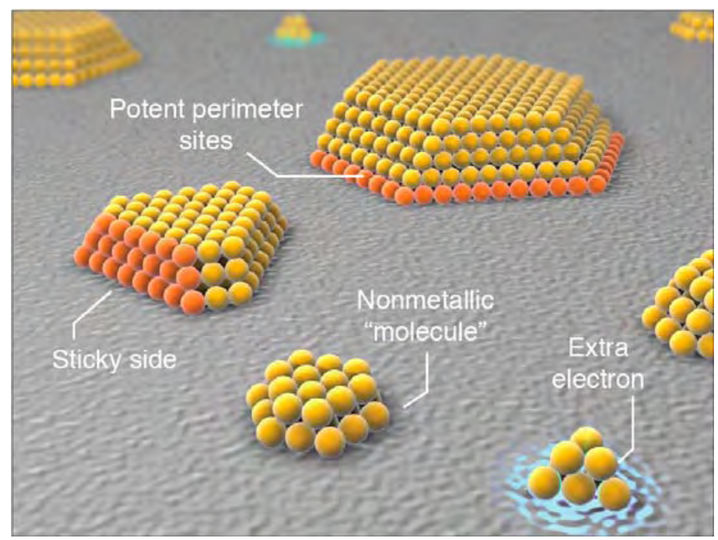
- GDL
  - Nano-capillary regimes
    - wettability of poorly defined, irregular materials
  - Lifetime changes in GDL
    - Loss of hydrophobicity

Recommended for Future Funding

- General
  - Role of nano-structure and its propagation to larger length scales
    - Means of preparing controlled structures
    - New tools for evaluating complex composite media
  - Standardized measurement methods
    - Durability/accelerated lifetime protocols
  - Promote Int'l collaboration
    - Make sure there is research money for bilateral collaborations
    - Education: Researcher exchanges between Japanese and U.S. institutions; Joint 'Institutes' and workshops for training

Hydrogen Conversion and Storage Breakout Session





NSF-MEXT Meeting on Fuel Cells and Related Technologies

Hydrogen Conversion and Storage
Breakout Session

Broad Objectives [Mission Statement]

Laying the Foundation for Collaborative Research

- Improve efficiency and cost effectiveness of hydrogen production from fossil and renewable fuels with purity levels appropriate for fuel cells.
- Discover better performing, multifunctional catalysts including development of water electrolysis catalysts
- Meet cost and performance targets for hydrogen storage necessary for transportation applications
- In situ or operando probes and methods to enhance understanding of functioning catalysts (Surface and bulk nano-characterization}
- Fostering student and post-doc exchange and sharing of protocols (idea is to broaden the educational and research experience of students)
- Nano-engineered materials and interfaces to conventional and non conventional applications.

Broad Challenges

- Understanding mechanisms
  - catalytic hydrogen production (many are multifunctional; understanding mechanism could yield new catalyst designs)
  - deactivation of catalysts (many of more active materials suffer from deactivation; should engage industrial researchers to address some of these issues)
  - hydrogen storage and recovery capacities, reversibilities and rates
- New materials
  - Stable and durable high performance reforming, water gas shift and CO clean-up catalysts for hydrogen production from conventional and renewable fuels including electrolysis
  - High temperature durability, pin-hole free, and cost effective membranes form hydrogen purification
  - High rate, high capacity and highly reversible hydrogen storage materials

Broad Future Challenges

- Higher activity catalysts and storage materials
- Materials with enhanced durability
- Improved hydrogen storage and release rates
- Catalysts for reforming new fuels
- Safety
  - Perceived
  - Real

Recommendations for Future Funding

- Establish collaborations of experts in chemical (reforming) catalysis and electrochemical catalysis research
- Establish collaborations for advanced characterization of materials for hydrogen production and storage, especially under conditions expected in operation
- Explore the use of new fuel sources
- Discover and develop more durable catalysts and storage materials (involves understanding the mechanisms)
- Develop base metal catalysts that rival noble metal catalysts