2006 DOE Hydrogen Program Dimensionally Stable High Temperature Membranes

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This presentation does not contain any proprietary or confidential information

Project ID #
FCP 16

Overview

Timeline

- Begin 4/3/2006
- Review 4/2/2009
- <10% Complete

Budget

- Total project funding (to 2009)
  - $899K DOE Funding
  - $529K Recipient
  - 37% Cost Share
  - $150K 2006

Barriers addressed

A. Durability
B. Cost

Technical Targets (DOE 2010 Targets)

- 0.10 S/cm at 1.5 kPa H_2O Air inlet
- <$40/m^2
- > 5000 h lifetime
- Stability in Condensing conditions

Partners

- General Motors

Objectives

Overall:

Generate 2-dimensional and 3-dimensionally stable PEMs (2DSM and 3DSM, respectively) that meet DOE targets for performance, cost and durability.

2006

2DSM: Determine the effect of pore size and substrate thickness on conductivity, water uptake and mechanical properties for two-dimensional stable membranes

3DSM: Determine polymerization pathways for bulk polymerization of perfluorosulfonic acids.

2007

2DSM: Demonstrate DOE target feasibility for performance

3DSM: Conduct bulk polymerization of PFSA in micro-supports

2008-9

2DSM: Demonstrate DOE target for durability, outline pathway for costs

3DSM: Demonstrate Ability to make in large scale, meet DOE performance targets

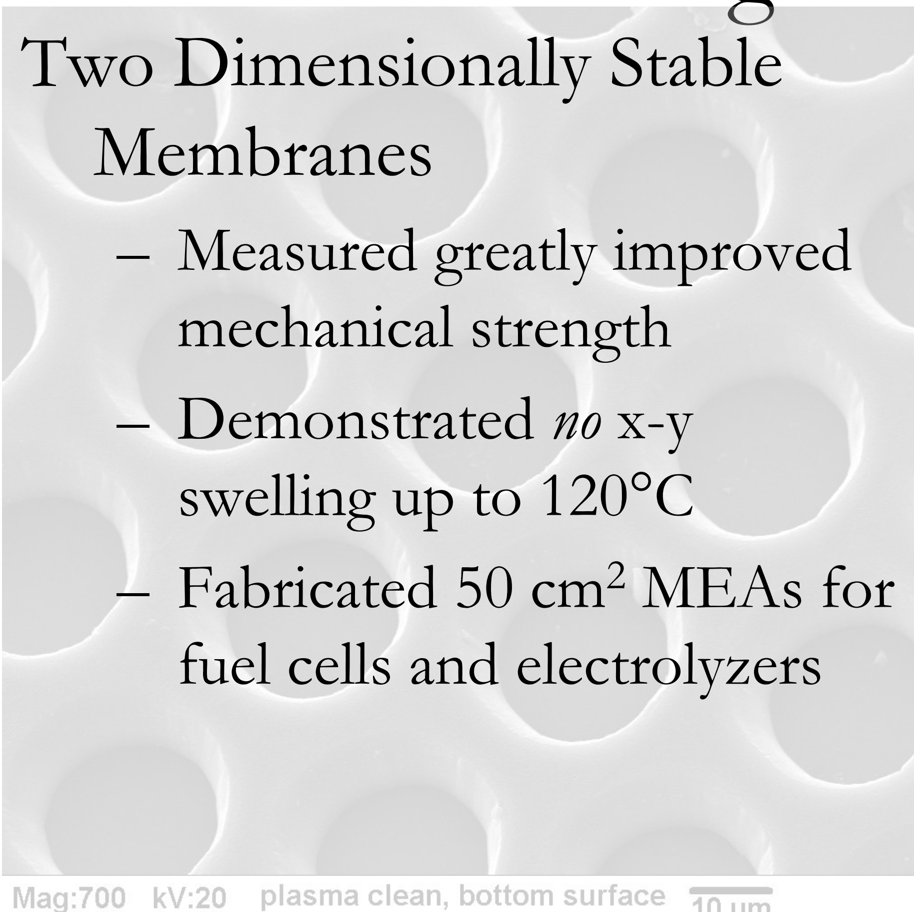
Approach: Lower EW of perfluorosulfonic Acid ionomers to increase low RH conductivity and support the ionomer with two and three-dimensional non-ionic materials

- Two Dimensionally Stable Membrane
  - Generate Supports
    - Thickness and Pore Size
  - Incorporate Ionomers
    - 700 to 1100 EW PFSA
  - Characterize
    - Performance
    - Durability
    - Cost

Mag:700 kV:20 plasma clean, bottom surface 10 μm

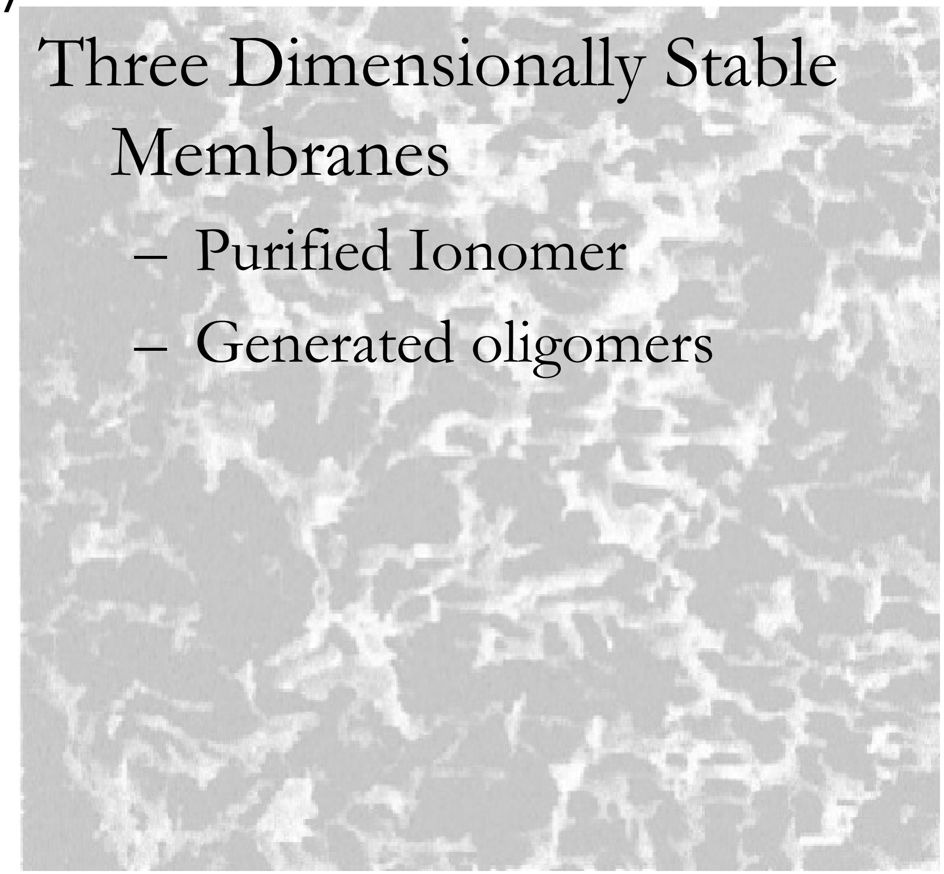
- Three Dimensionally Stable Membrane
  - Develop Bulk Polymerization Methods
  - Polymerize in Selected Supports
  - Characterize
    - Performance
    - Durability
    - Cost

Technical Accomplishments/ Progress/Results



Two Dimensionally Stable Membranes

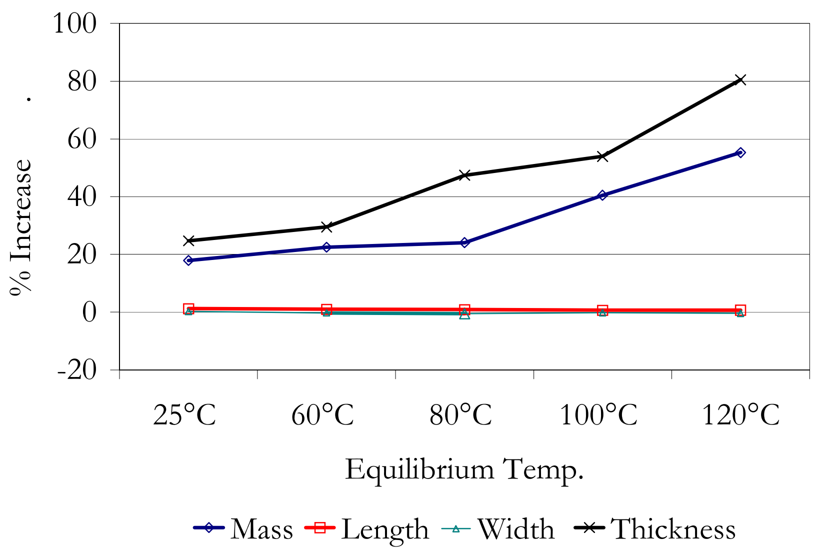
- Measured greatly improved mechanical strength
- Demonstrated *no* x-y swelling up to 120°C
- Fabricated 50 cm^2 MEAs for fuel cells and electrolyzers



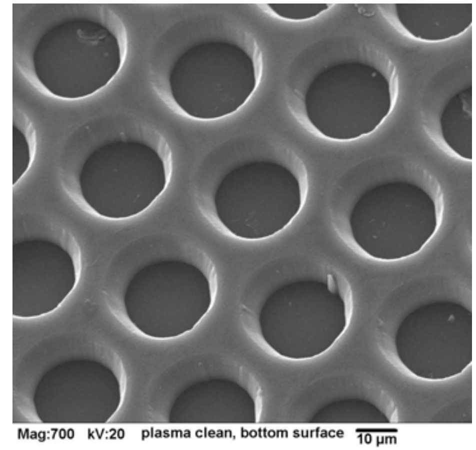
Three Dimensionally Stable Membranes

- Purified Ionomer
- Generated oligomers

Accomplishments/Progress

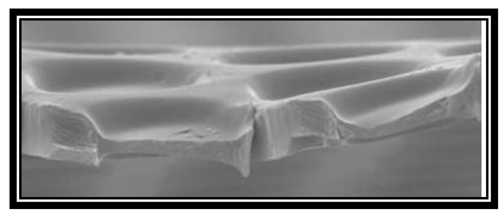


Dimensional and mass increase of composite membranes consisting of 1100 EW PFSA incorporated in 8- μm polyimide support seen in adjacent figure.

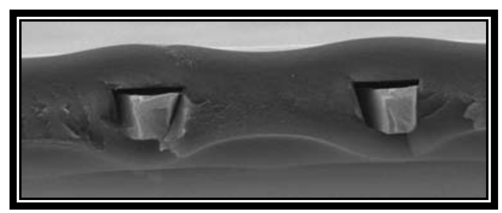


Porous Support

- polyimide
- 8μ thick
- 50% open
- 20μ holes



Surface Tension leads to uniform filling of holes during casting



Addition of more ionomer leads to desired PEM thickness

Future Work

- 2006
  - Highlights will be to fabricate and characterize matrix of 2DSM
    - Pore size
    - EW
    - Thickness
  - Bulk Polymerization for 3DSM
- 2007
  - Demonstrate ability to make performance targets
- 2008
  - Demonstrate ability to make cost and durability targets

Summary

RELEVANCE: PFSA's are currently the best PEM candidates in terms of low RH performance and chemical stability. However they still do not reach DOE performance and durability targets.

APPROACH: Extend the limit of PFSA's by increasing mechanical stability with non-ionomer support structures.

TECHNICAL ACCOMPLISHMENTS:

- Two Dimensionally Stable Membranes currently being generated
  - Perfect x-y dimensional stablility during hydration/dehydration cycling
  - Optimization of controllable parameters beginning
- Work on Three Dimensionally Stable Membranes just getting underway

- JUST GETTING STARTED

Critical Assumptions and Issues

- Cost of the Micro-supports
  - Current laser machining is greater than the cost of DOE targets for membrane cost
- Assuming a membrane that does not swell in the x-y plane will lead to greater durability.
  - Some freeze-thaw and RH cycling already accomplished
- Bulk Polymerization of PFSA yet to be shown
  - Oligomers generated during first attempt