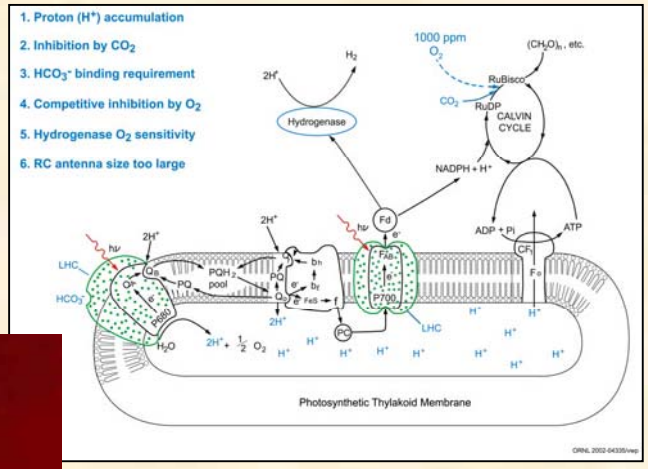
The Hydrogen Program Builds on Core Strengths

- **Modeling and Simulation**
- **Alloy Design/Materials Corrosion**
  - **Pipeline and weld materials**
- **H_2 Separation**
  - **Microporous membranes**
  - **Ion transport membranes**
- **Gas Cleanup**
  - **Carbon fiber composite sieves**
  - **Desulfurization catalysts**
- **Renewable Production of H_2**
  - **Algal production of H_2**
  - **Enzymatic production of H_2 from glucose**
  - **Photolysis**

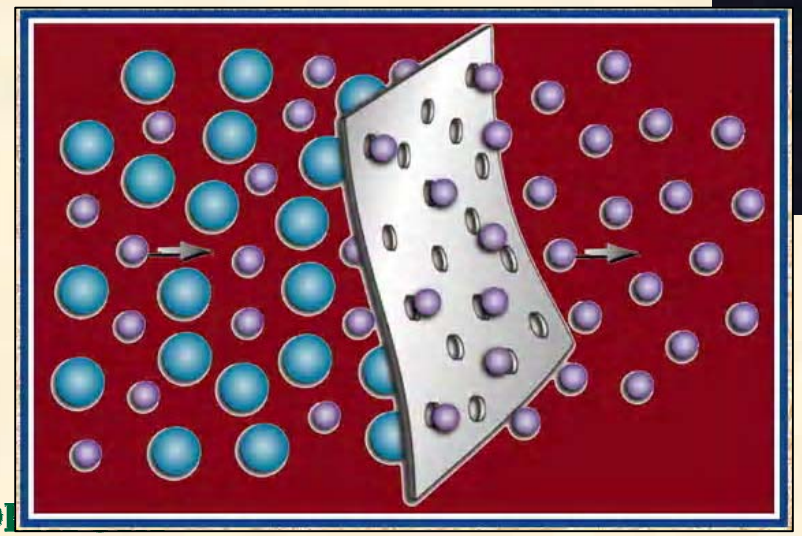


Development of a Porous Inorganic Membrane Hydrogen Separation Device

Objective/Challenge

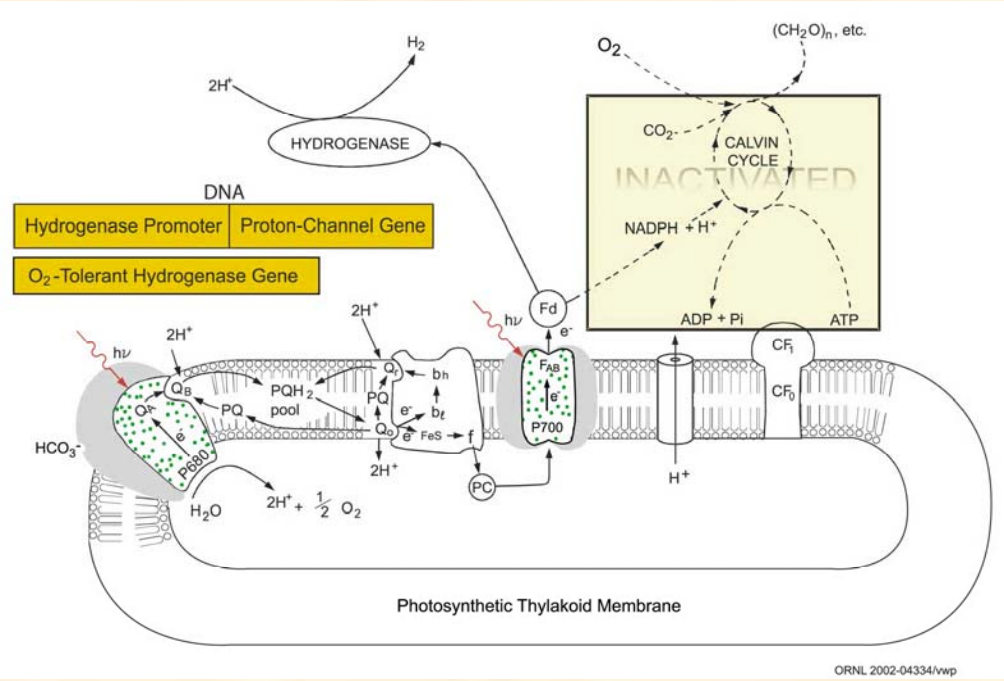
- Develop a Compact and Efficient Hydrogen Separation Device for the Purification of Hydrogen
- Develop, Through Experimental and Theoretical Approaches, Gas Separation Membranes that Meet Rigorous Performance Criteria for Flux, Separation, and Hydrogen Purity

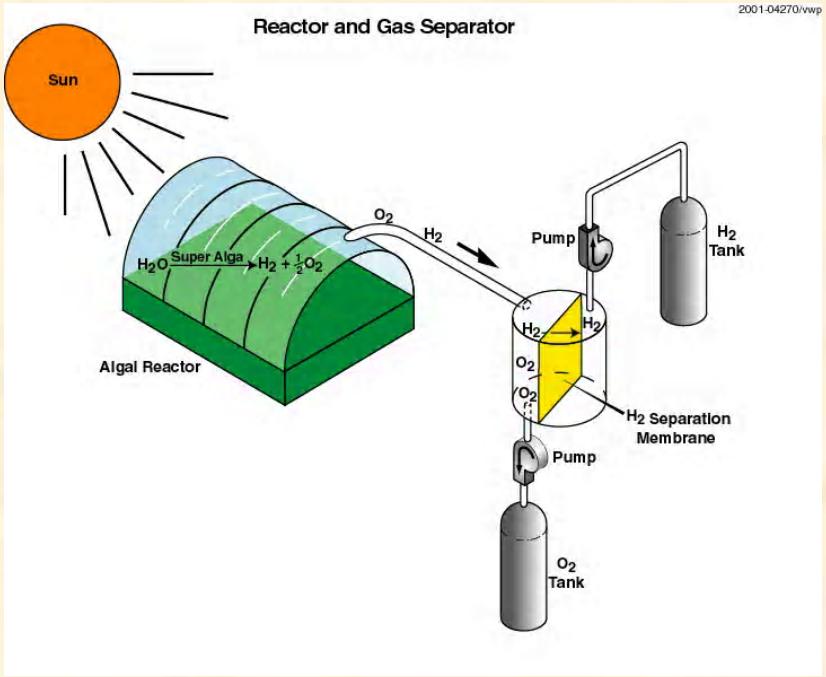
- Transport is via molecular diffusion
- Separation may occur by:
  - Molecular sieving
  - Knudsen diffusion
  - Surface flow



Development of Efficient and Robust Algal H_2-Production Systems

- In this project, a "designer alga" will be created for efficient and robust production of H_2 by genetic insertion of a hydrogenase-linked proton channel into the thylakoid membrane at ORNL.
- This designer alga will be integrated also with the benefits of an O_2-tolerant hydrogenase that will be created by NREL and a smaller chlorophyll antenna size that will be created by UC Berkeley.





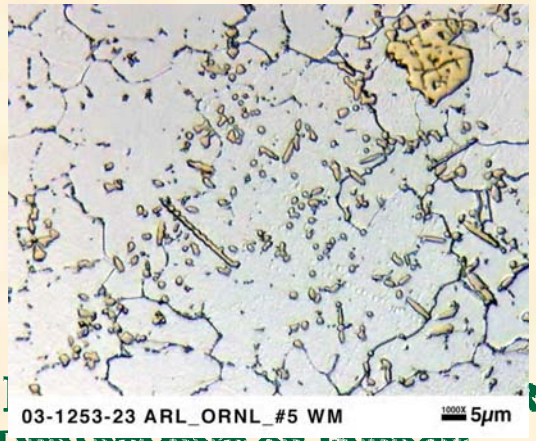
New Materials and Joining Technology for Hydrogen Pipelines

- Most economical approach would be to extend the steel pipeline concepts developed for natural gas delivery to hydrogen delivery.

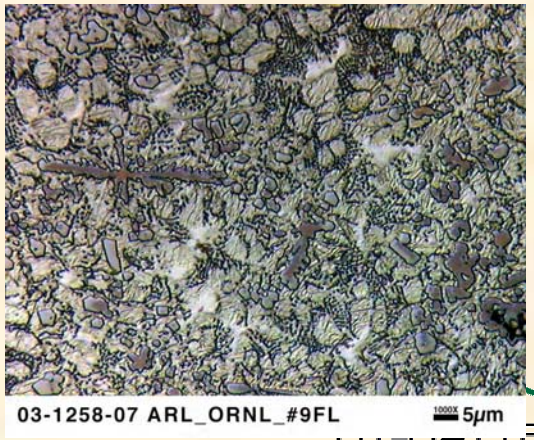
Challenges

- Requirements for using high pressure differential to transfer hydrogen from reforming area to dispensing stations.
  - –High pressure differential leads to increased hydrogen diffusion through pipeline material and, as a result, increased cracking and/or leakage.
  - –Large amounts of diffusible hydrogen also leads to increased potential for hydrogen assisted cracking in hardened microstructure zones

Goal - Develop materials for improved hydrogen management

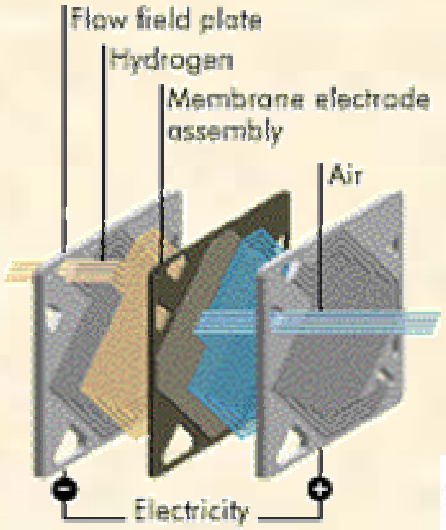


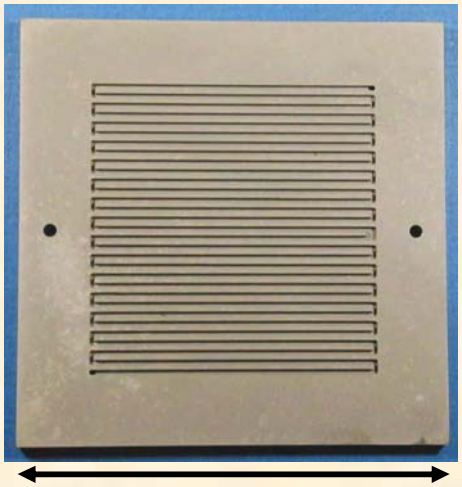
Microstructural engineering by material - process modifications can be carried out to change hydrogen permeability through welds



ORNL's Hydrogen Fuel Cell Program Focuses on Component Development

- Metallic and carbon bipolar plate development
- Carbon based heat exchangers
- Fiber optic temperature sensors
- Sulfur mitigation/catalysts
- MEA Characterization
- Development of high-temperature (150°C) polymer membranes





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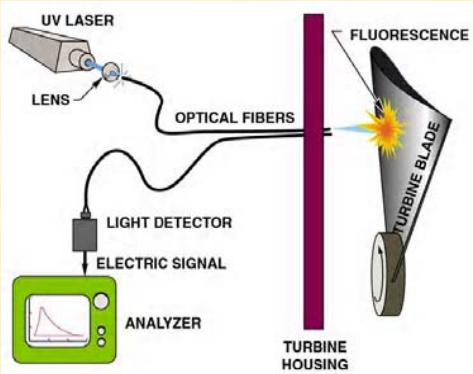
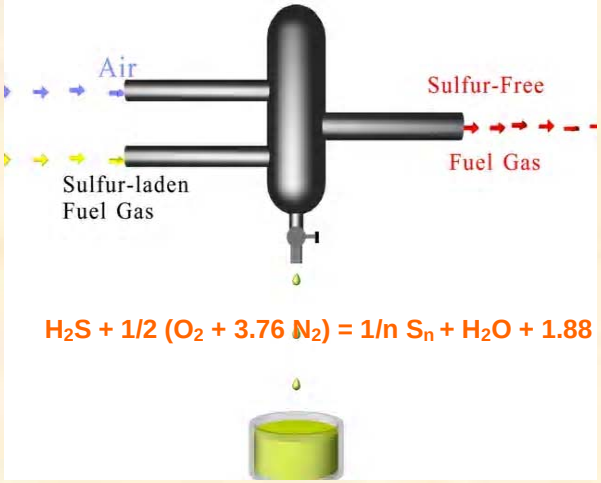
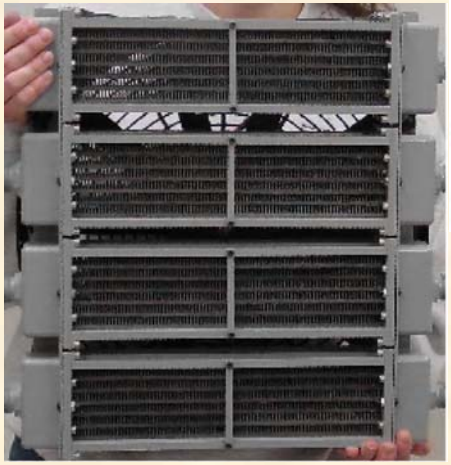
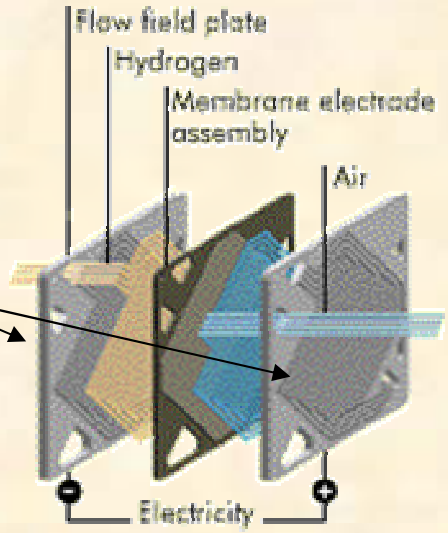






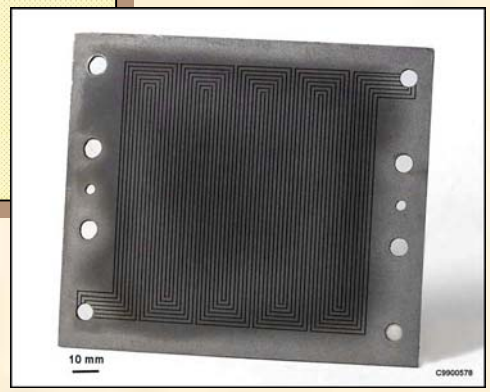
Carbon Composite Bipolar Plates for Automotive PEM Fuel Cells Meets Cost and Performance Goals

Bipolar Plate is
- *Cell electrode*
- *Sealing surface*
- *Flow field for gas*



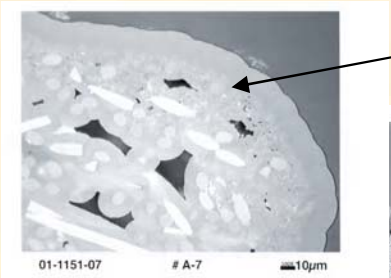
PEM Fuel Cell

Advantages of Approach
- *Continuous or semi-batch process*
- *Low corrosion rate*
- *Low cost (less than $2/plate)*
- *High electrical conductivity*
- *Impermeable*
- *Thin (2.5 mm)/lightweight*
- *Built in flow field*

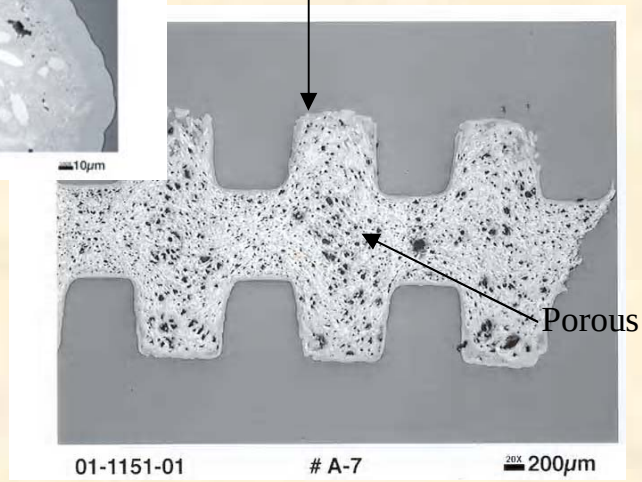


Bipolar Plate

Bipolar Plates Must
- *Be low cost*
- *Not corrode*
- *Have high electrical conductivity*
- *Have sufficient strength*
- *Prevent gas leakage*



Sealed Surface



Porous Volume

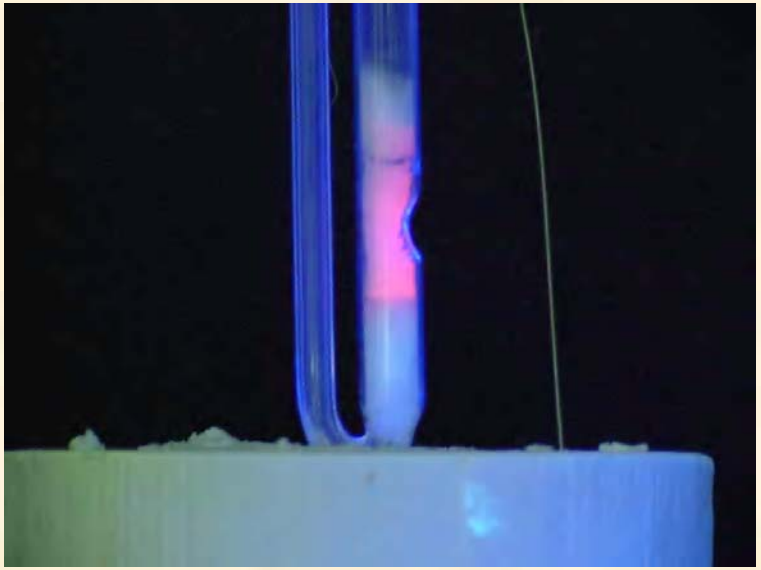
Cross-Section of Bipolar Plate

Technology Transfer
- *Lciensed to Porvair Fuel Cell Tech.*
- *Being evaluated by:*
  - *International Fuel Cells*
  - *Honeywell*
  - *PlugPower*

Development of a Hydrogen Gas Sensor for Use with Hydrogen Storage Vessels

Objectives: Develop a hydrogen-gas sensor for use with high-pressure hydrogen storage tanks (10,000+ psi); achieve DOE technical targets for H2 sensors in ambient air (safety sensor); overcome limitations of existing (palladium-based) hydrogen sensors.

Project Plan: Evaluate sensors developed at ORNL (including optical fiber based sensors) with respect to their effectiveness, potential cost, and reliability; implement most promising sensor in prototype system for field testing and demonstration; develop commercialization plan during the design iteration phase; and transfer the sensor technology to private industry for manufacturing and distribution.



Nanophase phosphor in test cell, fluorescing in broadband UV light.

Accomplishments: Hydrogen sensitivity observed in bench-scale tests of nanophase phosphor; collaboration with Quantum Technologies established.