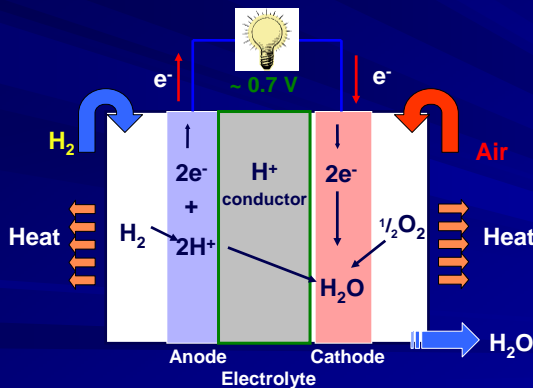


Lower-Cost Fuel Cells

Allen J. Bard, Arumugam Manthiram,
 José Fernandez, Vadari Raghuvier

Department of Chemistry and Biochemistry and
 Materials Science and Engineering Program

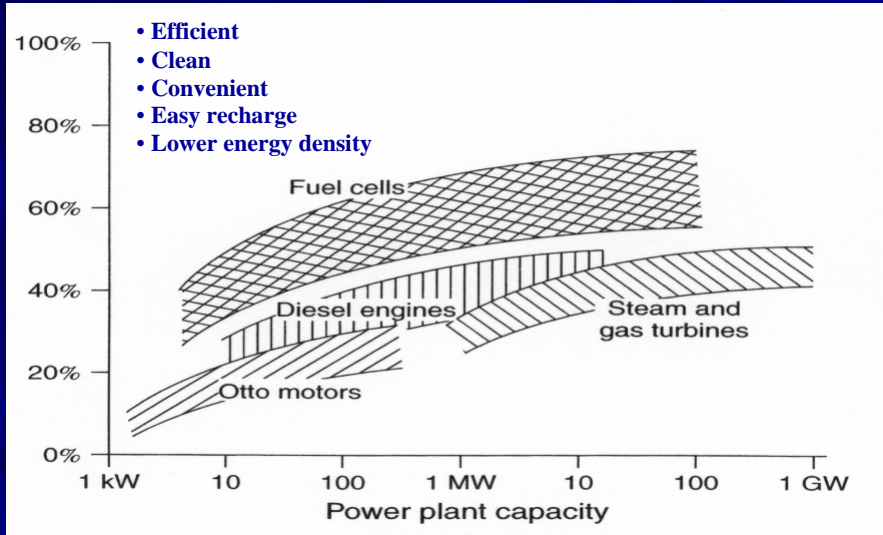
Fuel cells vs. conventional



- High efficiency
 - No Carnot limitation
- Environmentally friendly
 - Clean energy
- Quiet, modular, local
 - Watt to megawatt power

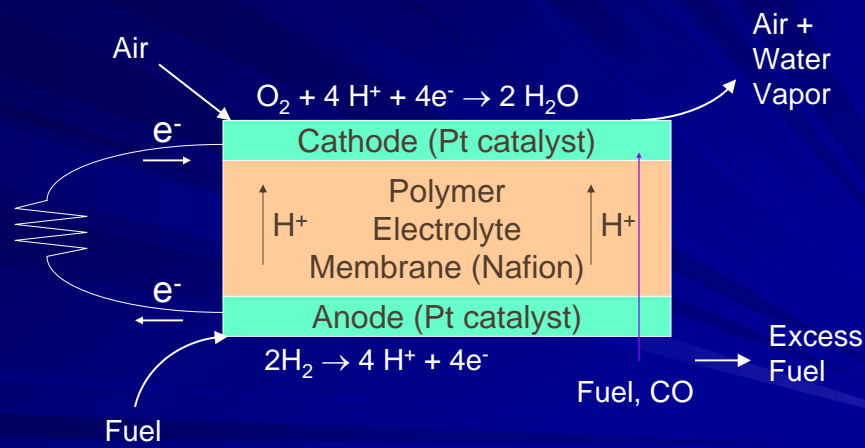
PEMFC: H₂ fuel
 DMFC: Methanol fuel

Fuel cells could change the world



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Hydrogen polymer electrolyte membrane fuel cell (PEMFC)



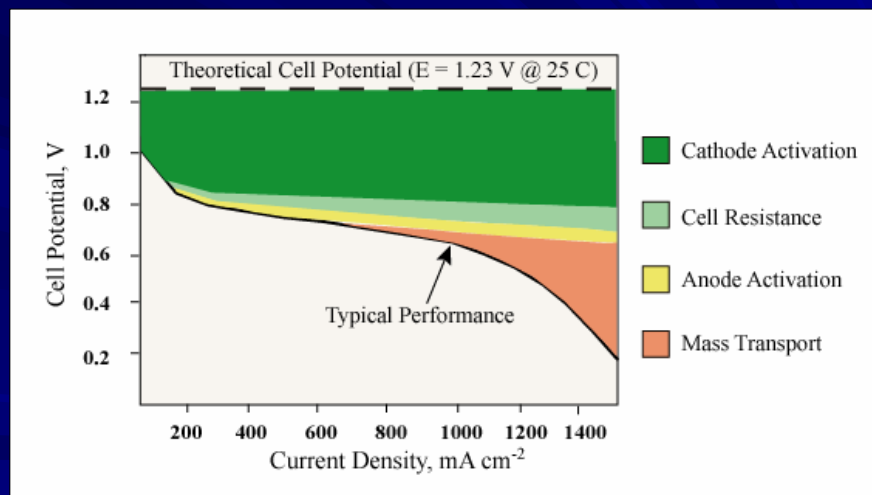
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Problem

- Fuel cells are of interest in many applications.
- Widespread commercial application requires the solution of problems with cost and stability.
- One important problem is the cost and limited availability of platinum metal—the only metal used so far for the oxygen reduction reaction in PEMFCs.

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Current O₂ cathodes are inefficient



Platinum Metals Rev. 2002, 46(1), 3.

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Solution

- Improved less expensive electrocatalysts, especially for the cathode (oxygen-reduction) reaction
 - High throughput screening of candidate materials
 - Testing in electrochemical and fuel cell environments
 - Improved synthetic methods
- Catalysts with better tolerance to methanol in DMFC

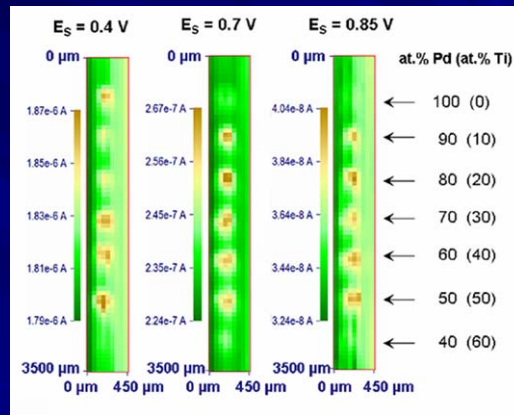
7

Technology overview

- Discovery of new electrocatalysts
- Pd-Co-Au and Pd-Ti
- Testing in polymer electrolyte membrane fuel cells (PEMFC)
- Performance comparable to Pt at significantly lower cost
- Better tolerance to methanol

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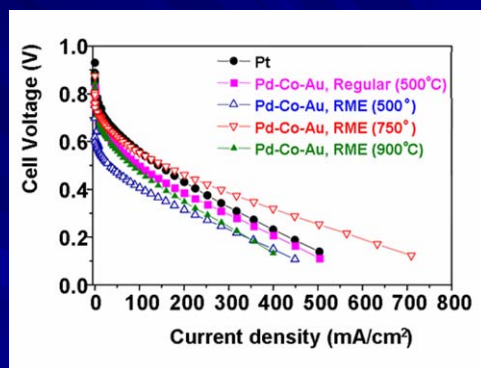
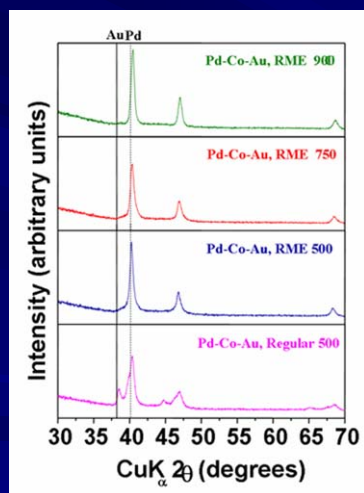
Rapid screening of binary PdTi electro-catalysts for O₂ reduction in 0.5M H₂SO₄



25 μm tip generating oxygen above an array of different compositions at different potentials. Tip-substrate distance = 30 μm , tip current = -171 nA, scan rate = 50 μm each 0.2 s. Potentials are vs. the hydrogen reference electrode.

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X-ray phase characterization and fuel cell performance

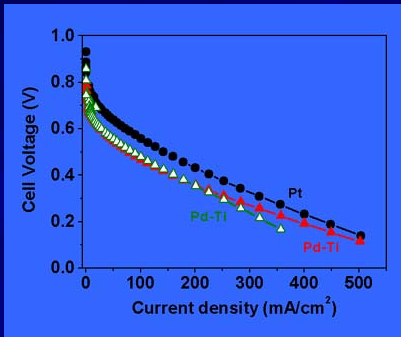


↑ PEMFC results with different preparation methods for Pd-Co-Au

⇔ Characterized by X-ray diffraction

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Comparison of steady-state polarization curves of the carbon supported Pd-Ti catalysts for ORR in single cell PEMFC with commercial (Johnson-Matthey) Pt catalyst



Data collected with Nafion 115 membrane, Pt anode catalyst loading of 0.2 mg/cm², humidifier temperature of 60°C, and a hydrogen and oxygen pressures of, respectively, 18 and 20 psi.

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Benefits

- Lower cost ($1/_{10}$ of current technology)
- Better methanol tolerance
- A path to better performance

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Market applications

- Three fuel cell markets (disruptive technologies)
 - Replace lithium-ion batteries
 - Notebook computers
 - Cell phones/other wireless applications
 - Replace internal combustion engines
 - Mobile applications
 - Replace power plants
 - Off-grid small power
 - Grid production (steam, hydroelectric)
- In 2001 fuel-cell companies attracted \$8.7 M in VC financing
- In 2004 investments to \$520 million

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Current market

- DOE funding fuel cells 2005
 - Advanced catalysts: \$32 million
 - Total: \$75 million
- Fuel cell industry will generate \$18.6 billion in sales by 2013 (ABI study)
- Current players:
 - Nuvant Systems Inc, Siemens-Westinghouse, Avista Labs, Nth Power, Chrysalix Energy, Neah Power Systems, Nu Element, Smart Fuel Cell, Medis

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Proposed NSF Materials Research Science and Engineering Center at UT

IRG 1: Membranes for PEMFC and DMFC

- Leader: Benny Freeman (Prof., Chem. Eng.)
- Chris Bielawski (Asst. Prof., Chemistry) Arumugam Manthiram (Prof., Mech. Eng.)
- Venkat Ganesan (Asst. Prof., Chem. Eng.) S. R. Narayanan (Group Leader, JPL)
- Lynn Loo (Asst. Prof., Chem. Eng.) Peter Rossky (Prof., Chemistry)

IRG 2: Catalysts and supports for PEMFC and DMFC

- Leader: Allen Bard (Prof., Chemistry)
- Richard Crooks (Prof., Chemistry) Arumugam Manthiram (Prof., Mech. Eng.)
- Graeme Henkelman (Asst. Prof., Chemistry) Keith Stevenson (Asst. Prof., Chemistry)
- Miguel Jose-Yacaman (Prof., Chem. Eng.) John White (Prof., Chemistry)

IRG 3: Catalysts and interconnects for SOFC

- Leader: John Goodenough (Prof., Mech. Eng.)
- Graeme Henkelman (Asst. Prof., Chemistry) Arumugam Manthiram (Prof., Mech. Eng.)
- Gyeong Hwang (Asst. Prof., Chem. Eng.) Keith Stevenson (Asst. Prof., Chemistry)
- Miguel Jose-Yacaman (Prof., Chem. Eng.) John White (Prof., Chemistry)
- Desiderio Kovar (Asst. Prof., Mech. Eng.)

Professors: 8

Natural Science: 7

Associate Professors: 1

Engineering: 8

Assistant Professors: 6

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Next steps

- Current status
 - Patent application filed
 - Lab/bench prototype is completed
- Commercialization opportunities
 - Start-up or license
- Follow-up meeting:
 - Wednesday, June 15, 1:00-2:00 pm

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