Novel, Combinatorial Method for Developing Cathode Catalysts for Fuel Cells

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This presentation does not contain any proprietary or confidential information

Project ID: # FCP9

Overview

Timeline

- Start Date: October, 2004
- End Date: July, 2006
- 15% Completed

Barriers

- Low activity of non-Pt catalysts
  - 2004 Status: 8 A/cm^3
  - 2010 Target: >130 A/cm^3

Budget

- Phase II SBIR
- Total Project Funding
  - $750,000
- 2004 Funding: $60,000
- 2005 Funding: $350,000

Partners

- Illinois Institute of Technology

Project Objectives

- **Develop a highly controlled method for accurate high-throughput evaluation of new catalyst materials.**
- **Scale up combinatorial approach: Sample preparation, screening system and data processing.**
- **Evaluate several families of catalysts for oxygen reduction activity.**
- **Scale up new, low-cost high-activity catalysts for evaluation in fuel cells.**

Why Combinatorial Approach for Catalyst Development?

- **Barriers to rational design.**
  - Complex surface chemistry.
  - Lack of a complete understanding of the reaction processes involved.
- **Many possible catalyst permutations (not confined by equilibrium phases).**
- **Screening in parallel allows for better evaluation of relative performance.**
- **Can potentially greatly reduce the cost of optimization and accelerate the discovery of new catalysts.**

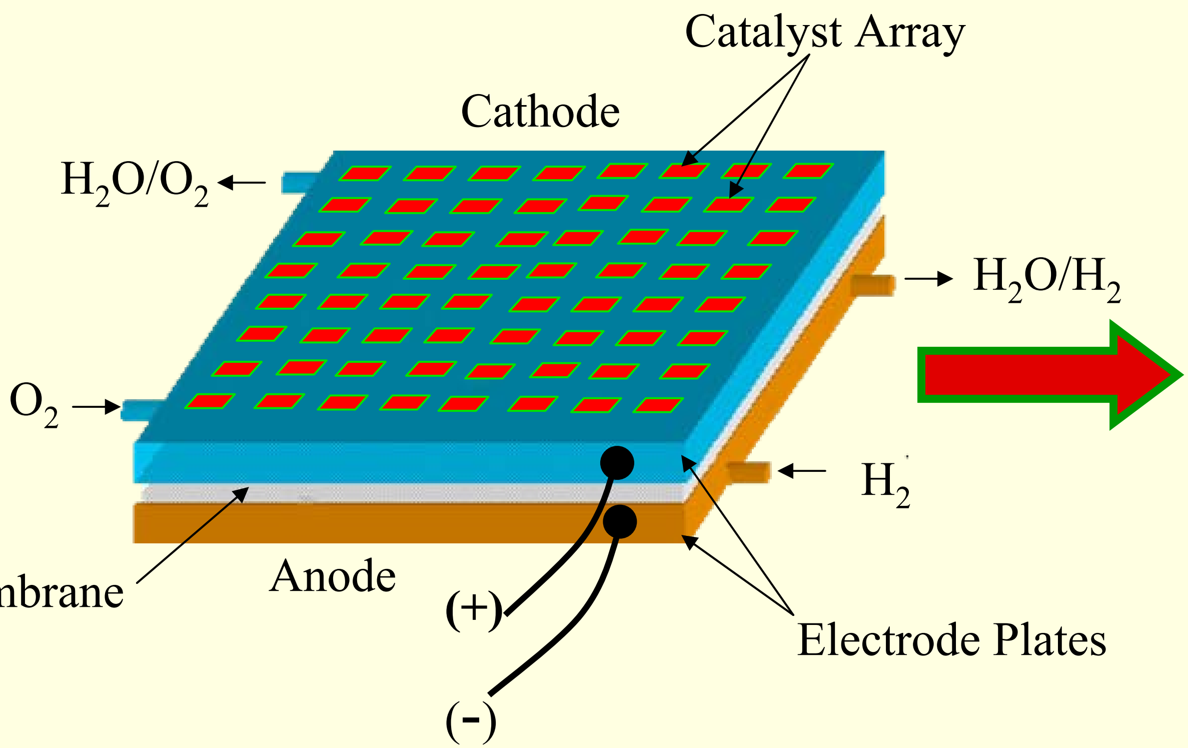
Barriers to Accurate Combinatorial Screening of Catalysts

- **Lack Control of Catalyst Morphology:**
  - Material variations not associated with chemical activity. *(surface area, morphology etc.)*
- **Lack control of MEA Structure:**
  - Slurry and coating variations affecting accessible active sites in the MEA. *(Catalyst wetting characteristics, surface area, morphology, etc, MEA porosity, loading etc)*
- **Non-uniform fuel distribution to catalyst samples.** (concentration changes downstream, MEA variations sample to sample etc.)
- **Testing conditions may complicate interpretation of results.**
- **Screening method limits type of catalysts that can be evaluated.**
- **Expense of assay.**

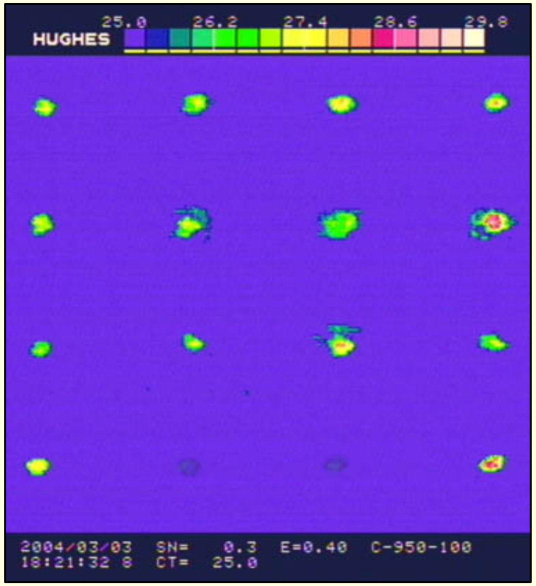
Technical Approach

Thermal Sensing

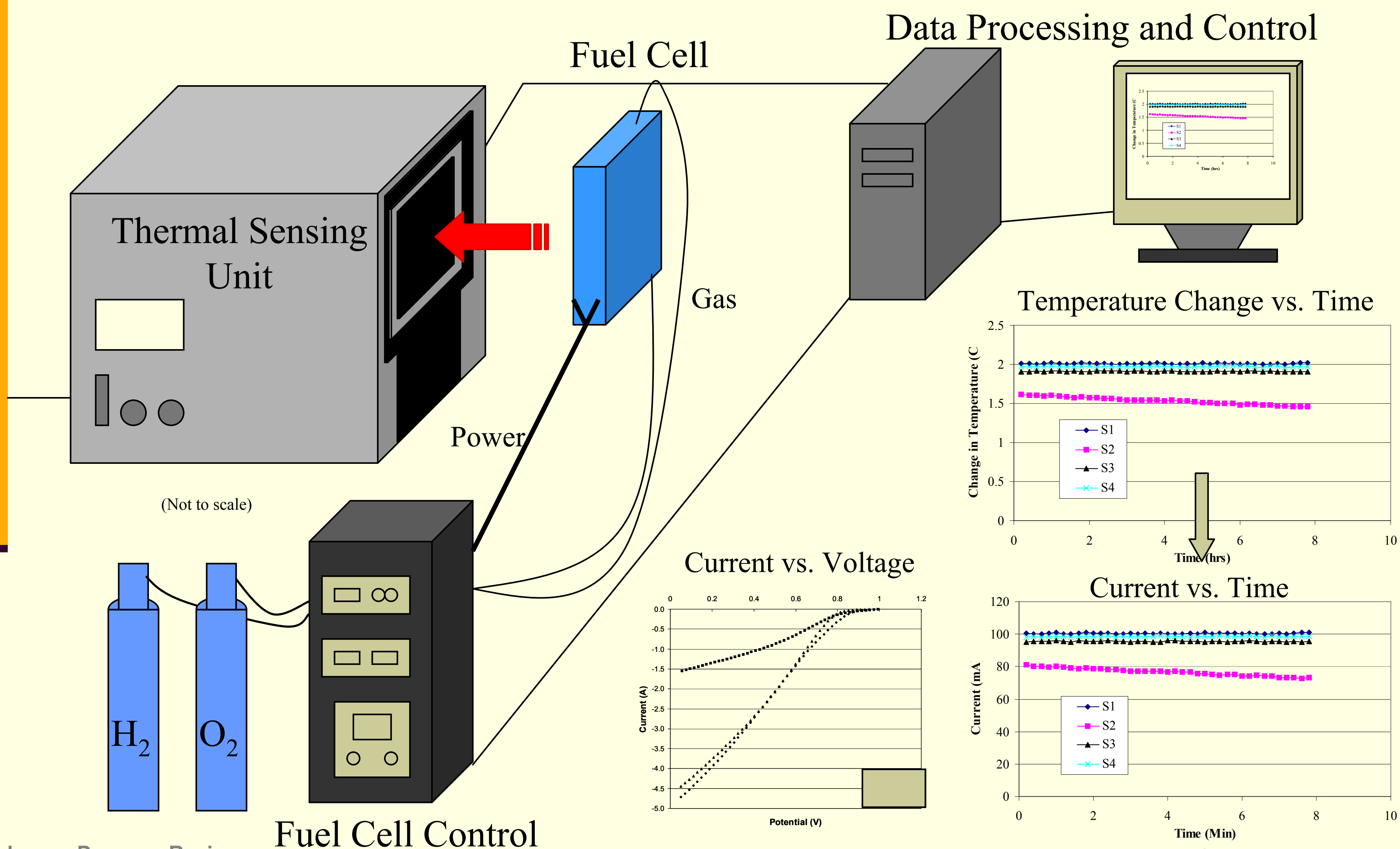
Thermal sensing allows for in-situ monitoring of individual catalysts samples in a closed fuel cell system.



Thermal Image



Fuel Cell Catalyst Screening System



Phase II Project Catalyst Development Strategy

- **Identify best chemistry first then optimize for utilization.**
- **Control all critical parameters to determine inherent catalyst activity.**
- **Use systematic DOE techniques to design catalyst array compositions and testing condition variables.**

Technical Approach Advantages

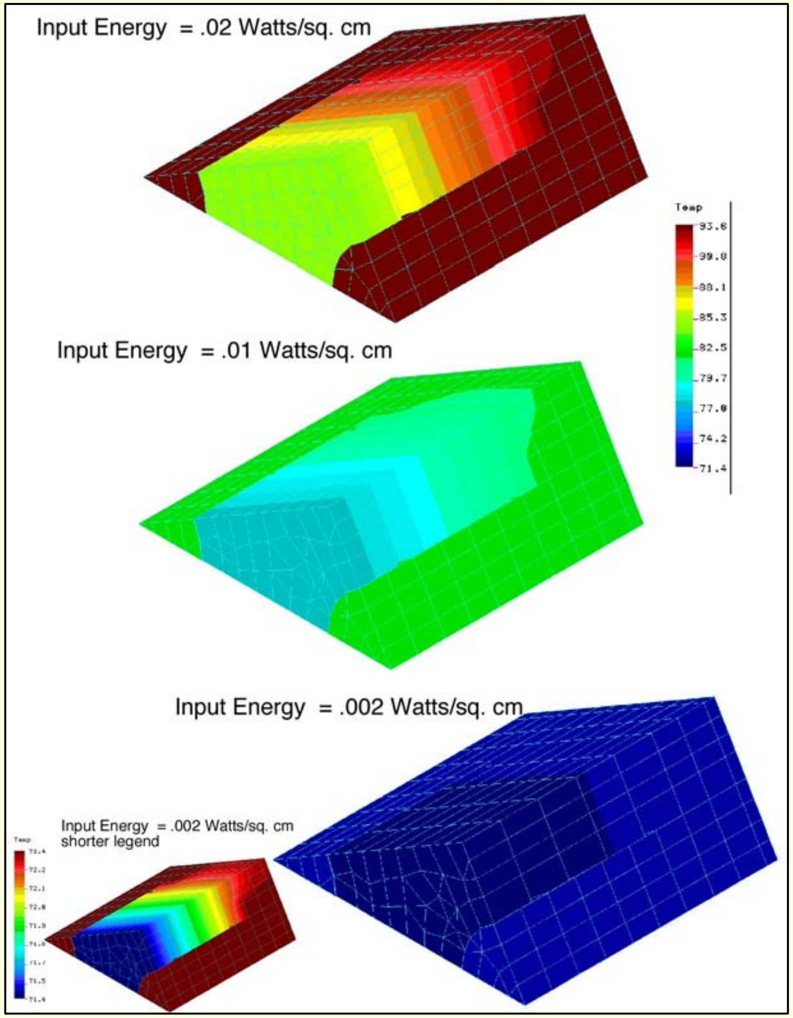
- No limitations on types of catalysts or which catalytic processes can be screened.
- In-situ screening under real operating conditions.
- Good control of critical parameters that affect fuel cell efficiency.
- Determine long term stability under real operating conditions.
- Easy sample preparation.
- Low cost.

Technical Accomplishments/ Progress/Results

- **Finalized screening system design and verified performance.**
  - Uniform stack pressure.
  - Uniform fuel distribution.
  - Uniform heat signal.
- **Progress on high throughput sample preparation system.**
- **Identified promising, high-activity non-Pt catalysts.**

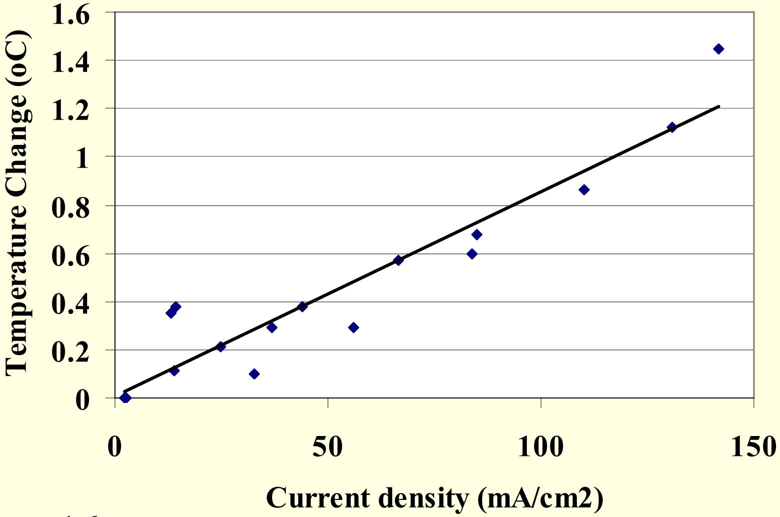
Thermal Modeling to Aid System Design

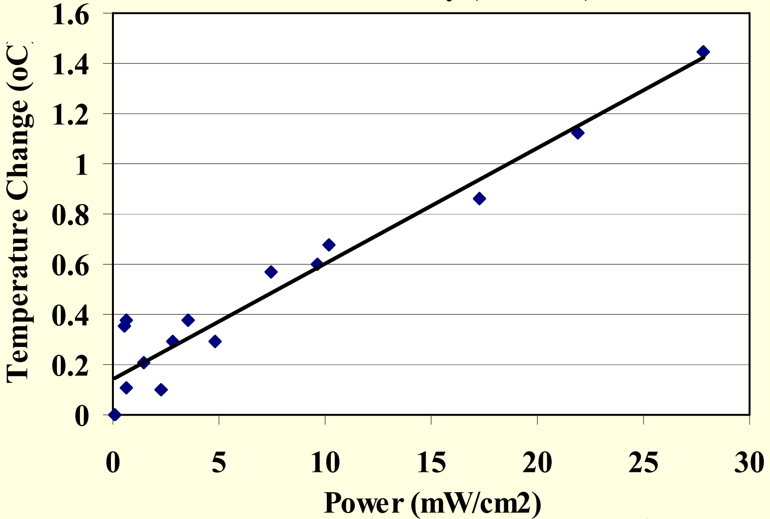
- **Developed design in miniature before scale up.**
  - 35 cm^2 array cell.
  - Accelerates development cycle.
  - Lowers cost of development.
    - Smaller MEA's
    - Fewer Samples.
    - Less Labor.



Verification of Thermal Signal Correlations

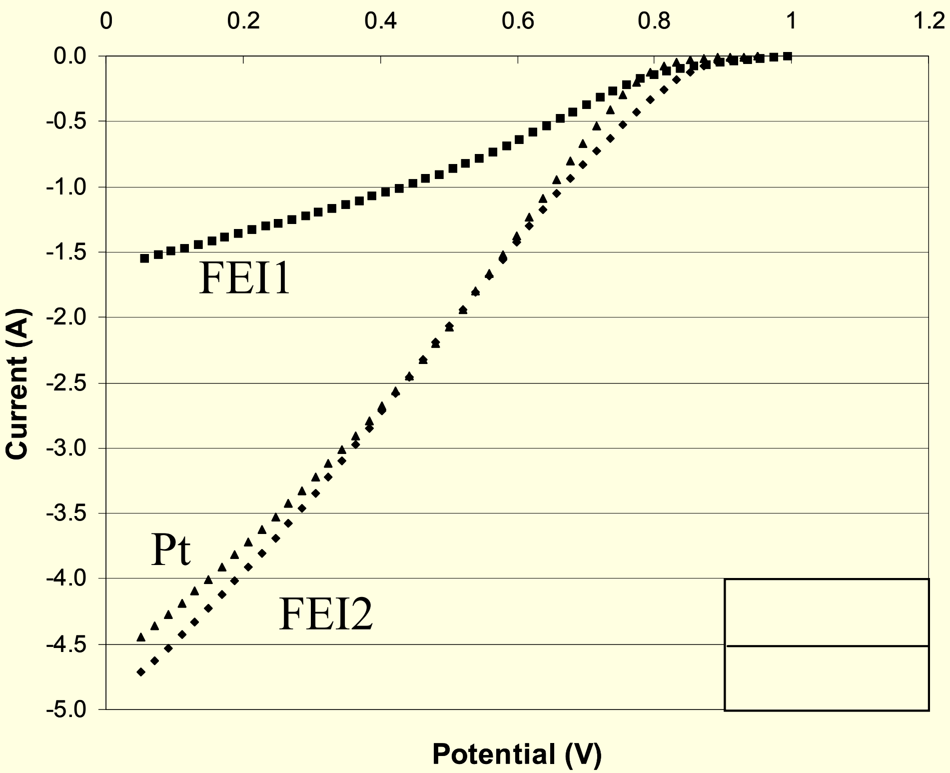
- Initial evaluation of thermal signal.
- Strong correlation between current/power density and catalyst sample temperature change.
- Sample temperature change was sufficient to detect by conventional methods.





Non-Pt Catalyst Family with High Activity

Verify Screening Results in Standard Fuel Cell



- **Temperature: 80°C**
- **Cathode gas: O_2**
- **Anode gas: H_2**
- **1mg Pt cm^{-2}**

Future Work

- Scale up screening system to 50-100 samples/cell.
- Continue data processing software development.
- Complete sample preparation systems.
- Continue large scale screening of non-noble metal catalysts.
- Verify results in standard fuel cells.

Hydrogen Safety

The most significant hydrogen hazard associated with this project is:

- Hydrogen is a combustible gas.
- Explosion hazard when mixed with air/oxygen.
- Hydrogen gas leaks from gas lines to fuel cells.

Hydrogen Safety

Our approach to deal with this hazard is:

- Installed hydrogen detectors.
- Protect system from potential ignition sources.
- Perform inert gas (N_2 or Ar) purging before hydrogen is introduced to line.
- Vent hydrogen according to standard regulations.
- Staff always present when hydrogen is being used.