2003 DOE Hydrogen and Fuel Cells Merit Review Meeting, May 19-22, 2003

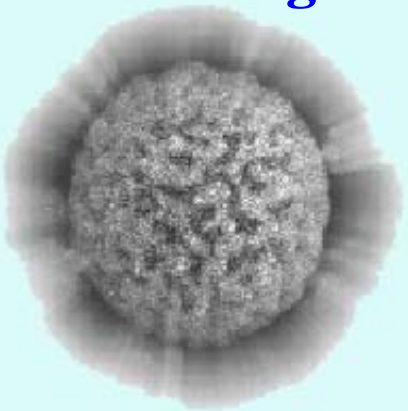
Title of Project: *Development of High-Performance, Low-Pt Cathodes Containing New Catalysts and Layer Structure*

Contractor: *Superior MicroPowders, LLC*

Duration: *4 years, September 2001- September 2005*

Award: *March 28th, 2002; DE-FC0402AL67620, Topic 1A1*

DOE Program Manager: *Valri Lightner*



Subcontractors: *DuPont Fuel Cells, CFDRC*

Stack Testing: *GM*

Principal Investigator: *Paolina Atanassova, Ph.D.*
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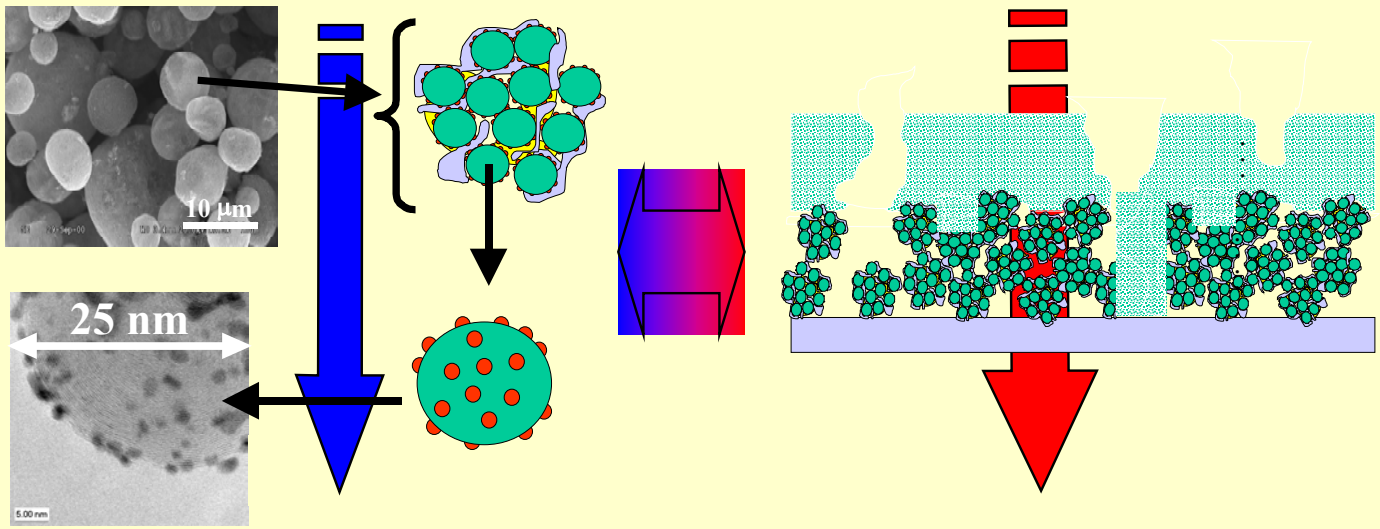
Approach - Technical Concept

Effort 1

Discovery of new, low Pt catalyst compositions and particle microstructures

Effort 2

Modeling and deposition of engineered cathode layers



High Performance Low-Cost MEA

- Effort 1:
  - *SMP*
  - *DuPont Fuel Cells*
- Effort 2:
  - *SMP*
  - *CFDRC*
- Short Stack Testing:
  - *GM*

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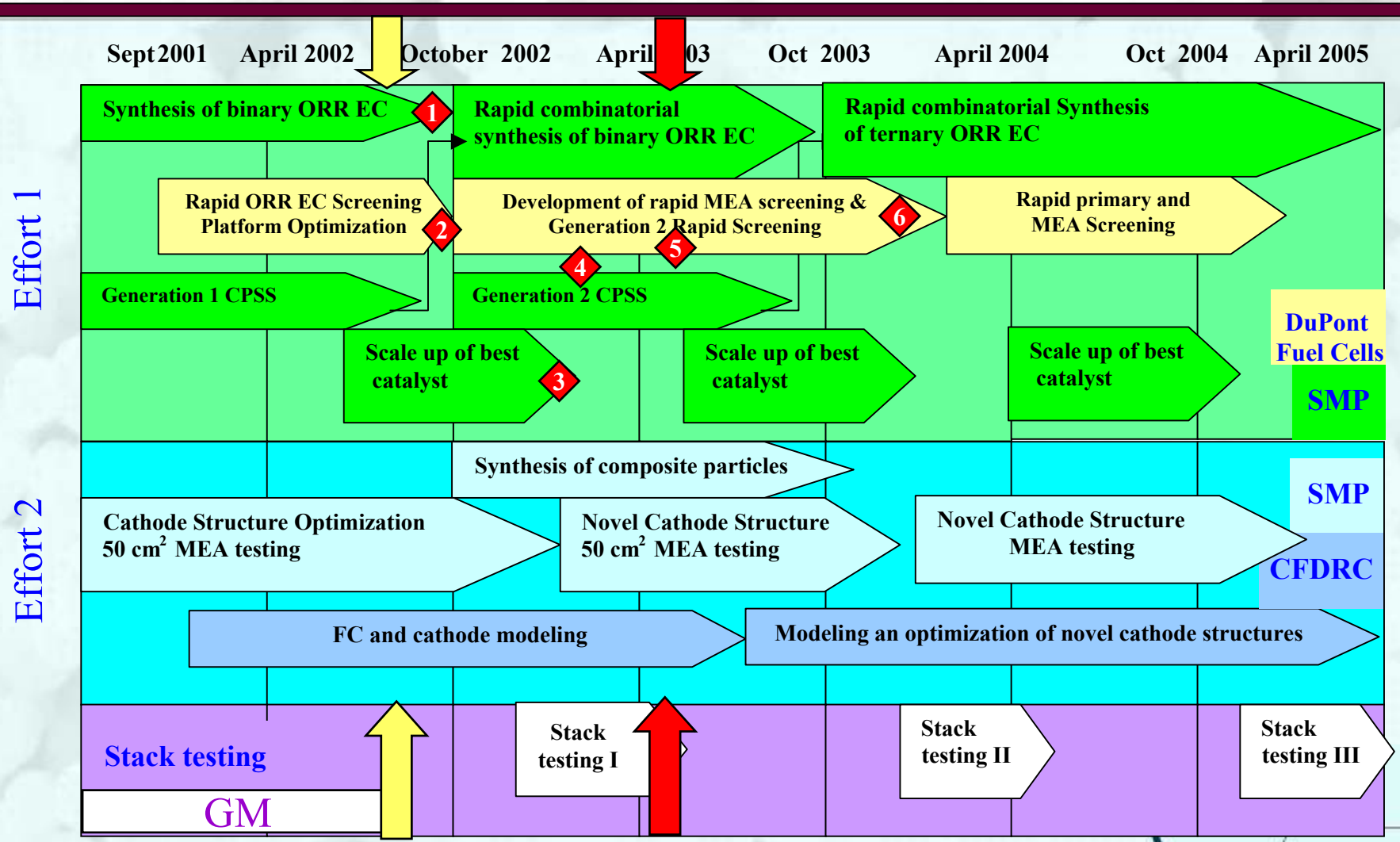
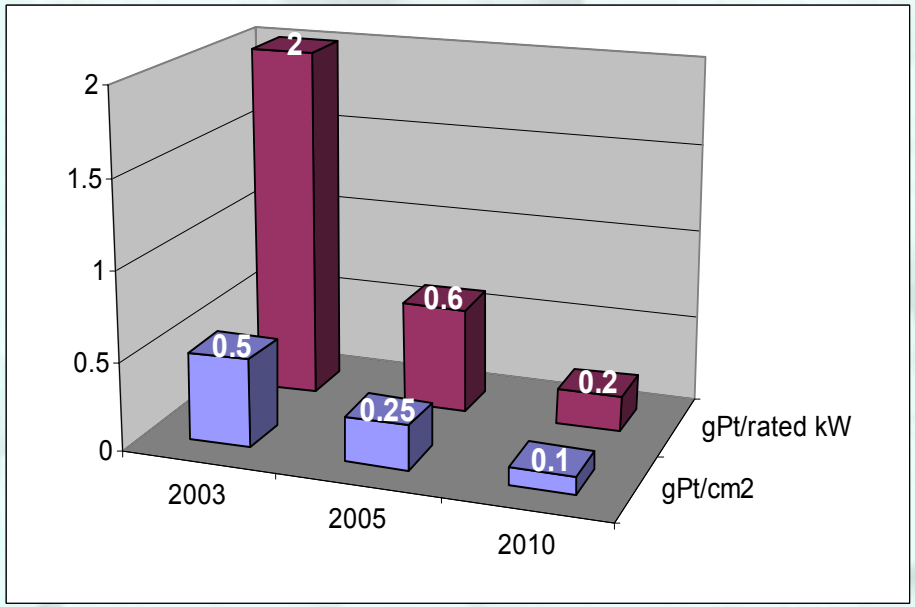
Project Timeline and Milestones



Relevance and Objectives



- Technical targets
- Technical Task 14:

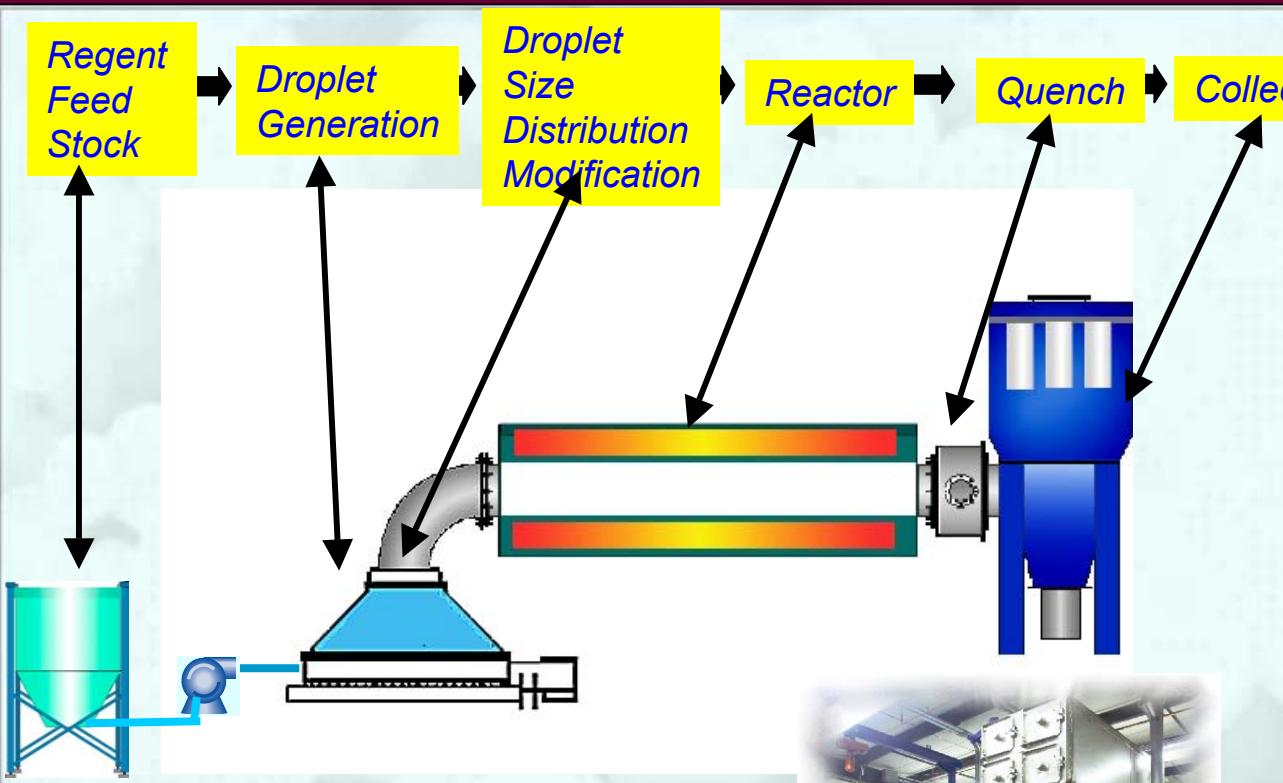
MEA Materials, Components, Processes

- Relevance to DOE Freedom CAR barriers and technical targets:

  Component technical barriers:

  - » Barrier O. Stack Material and Manufacturing Costs: low-cost, high-performance alternative oxygen reduction electrocatalysts
  - » Barrier Q. Electrode Performance: cathode voltage losses and higher power densities at higher voltages
  - » Barrier P. Durability: catalyst agglomeration and stability

Technology Platform: SMP's Spray Based Manufacturing



- Low cost manufacturing
  - » Single step processing
  - » Highly controllable and reproducible
  - » "Green" process with minimal waste streams
- Agile platform
  - » Complex compositions
- Ability to engineer critical properties
  - » Particle morphologies and size distributions
  - » Dispersion, crystallinity and size distribution of catalytically active phase

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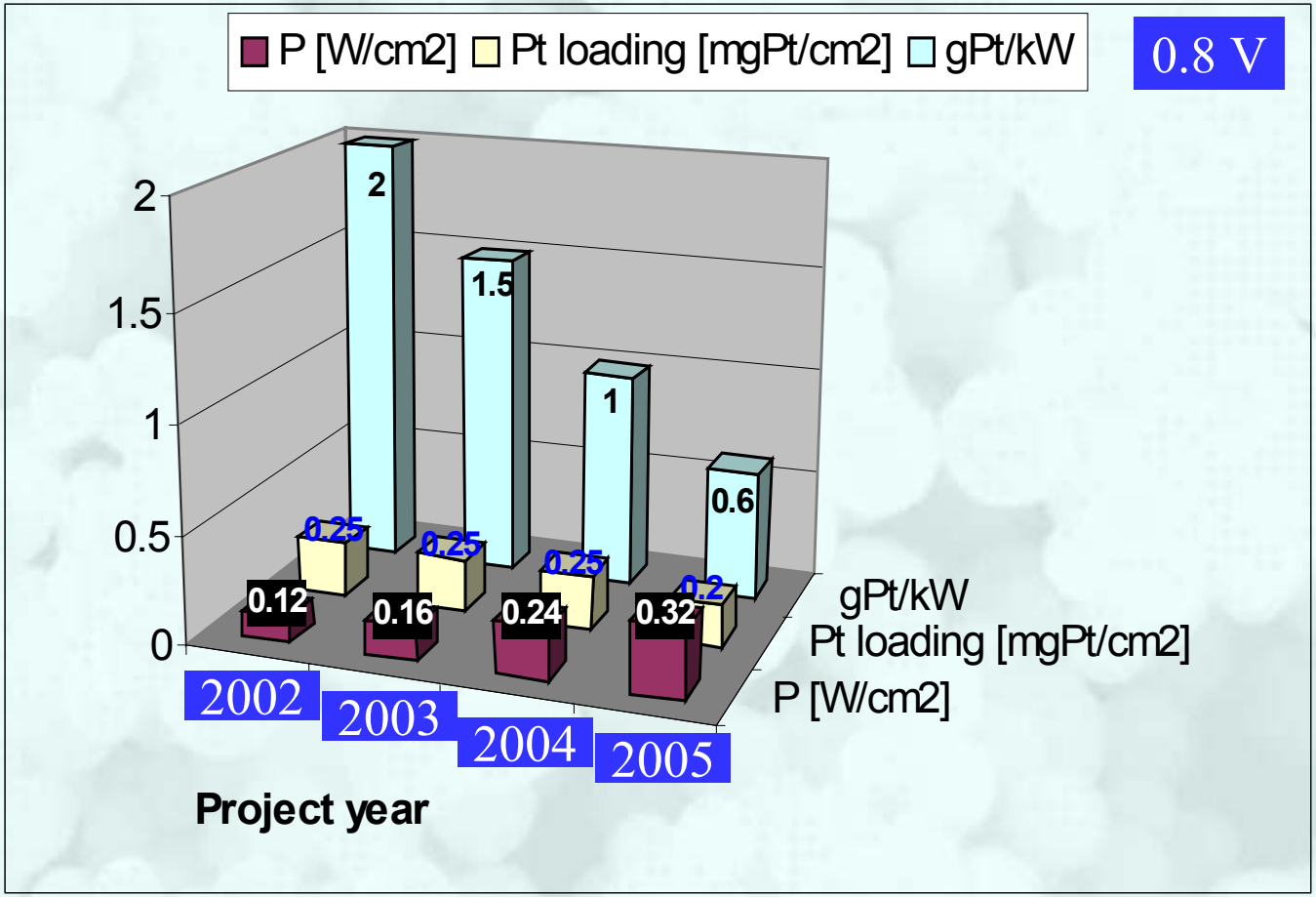
Project Performance Targets

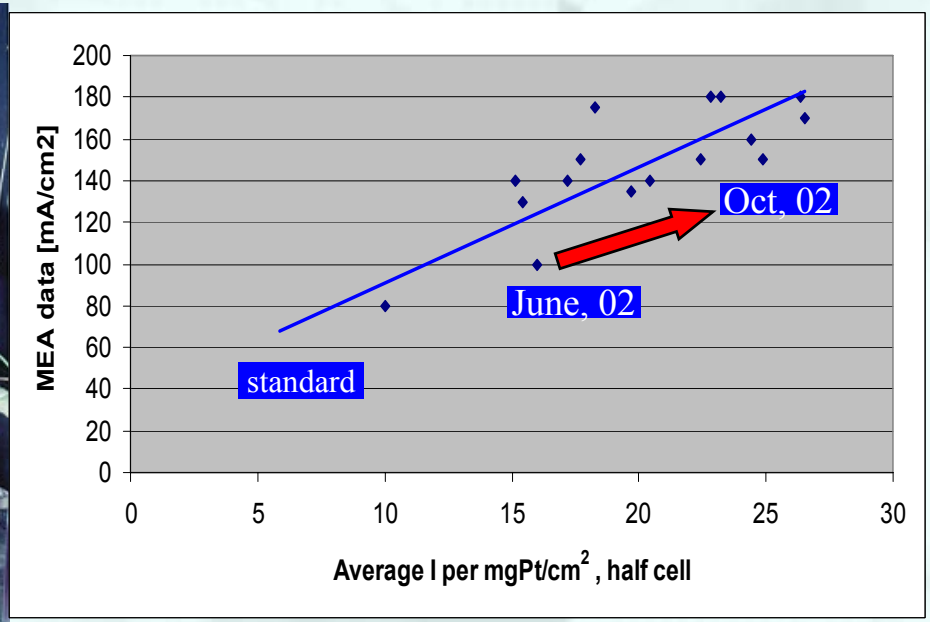


- *Single MEA 50 cm² test cell, Nafion 112*
- *Cell temperature 80C*
- *Anode/cathode constant flow rates = 510/2060 mL/min H_2/air (1.5H_2/ 2.5 air stoich at 1 A/cm²)*
- *30 psig pressure on both anode and cathode*
- *100% humidification of gases, 80 C dew points*
- *Galvanostatic,*

Summary of Achievements Effort 1 Combinatorial Approach

Milestone	Description	Achievement	Timing	Status
1	Synthesis of benchmark alloy catalysts by spray pyrolysis	Ability of spray approach to generate complex alloy catalysts with improved performance	October 2002	Up to 40 % improvement in terms of lower gPt/kW for $Pt_xNi_yCo_z$ ternary alloy system
2	Half-cell rapid screening approach optimization and benchmarking at DuPont	Correlation between ranking of catalysts and MEA performance and go-no-go decision criteria established	October 2002	Rapid screening used exclusively for initial screening of new catalysts

Summary of Achievements Effort 1 Milestone 2



Correlation of Half Cell Screening Data and MEA Performance

DuPont Fuel Cells

". . . powered by DuPont"

DUPONT The miracles of science

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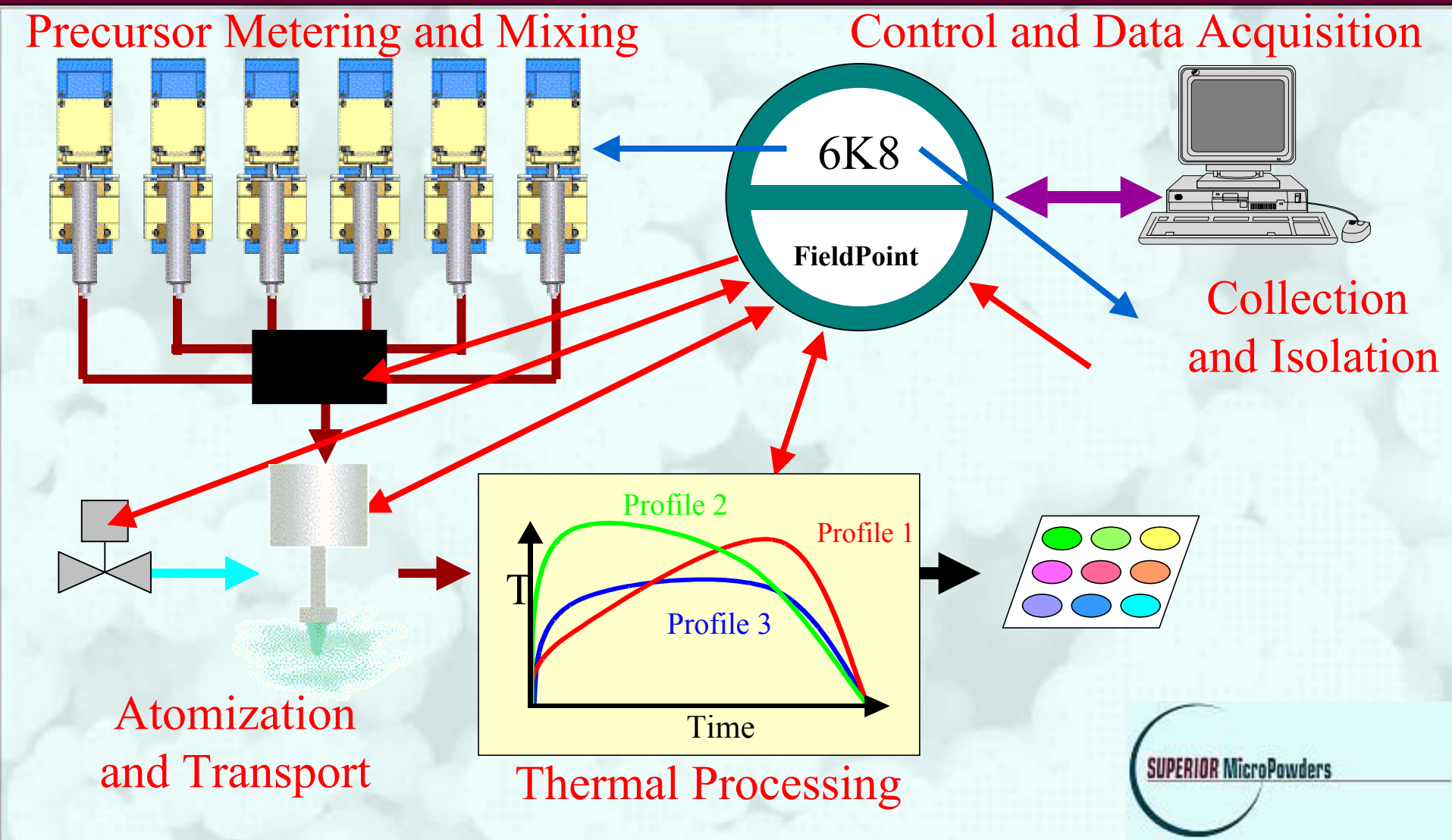
Summary of Achievements Effort 1 Combinatorial Approach

Milestone	Description	Achievement	Timing	Status
3	Scale up of best performing catalysts	High surface area Pt/carbon and Pt ternary alloy/carbon catalysts scaled up	January 2003	Performance of scaled up materials at least equal to small scale ones
4	Complete assembly of Combinatorial Powder Synthesis System (CPSS) and optimize parameters	System fully integrated and automated, target production rates achieved, Pt/C catalysts benchmarked	March 2003	100 samples per week at 0.25 g achievable, start to investigate broad number of alloy compositions and microstructures
5	Complete assembly of rapid ink formulation equipment at DuPont	System assembled, testing of baseline catalysts in progress	May 2003	75-150 samples per week testing rate achievable

Milestone 4: From Design to Functional Equipment



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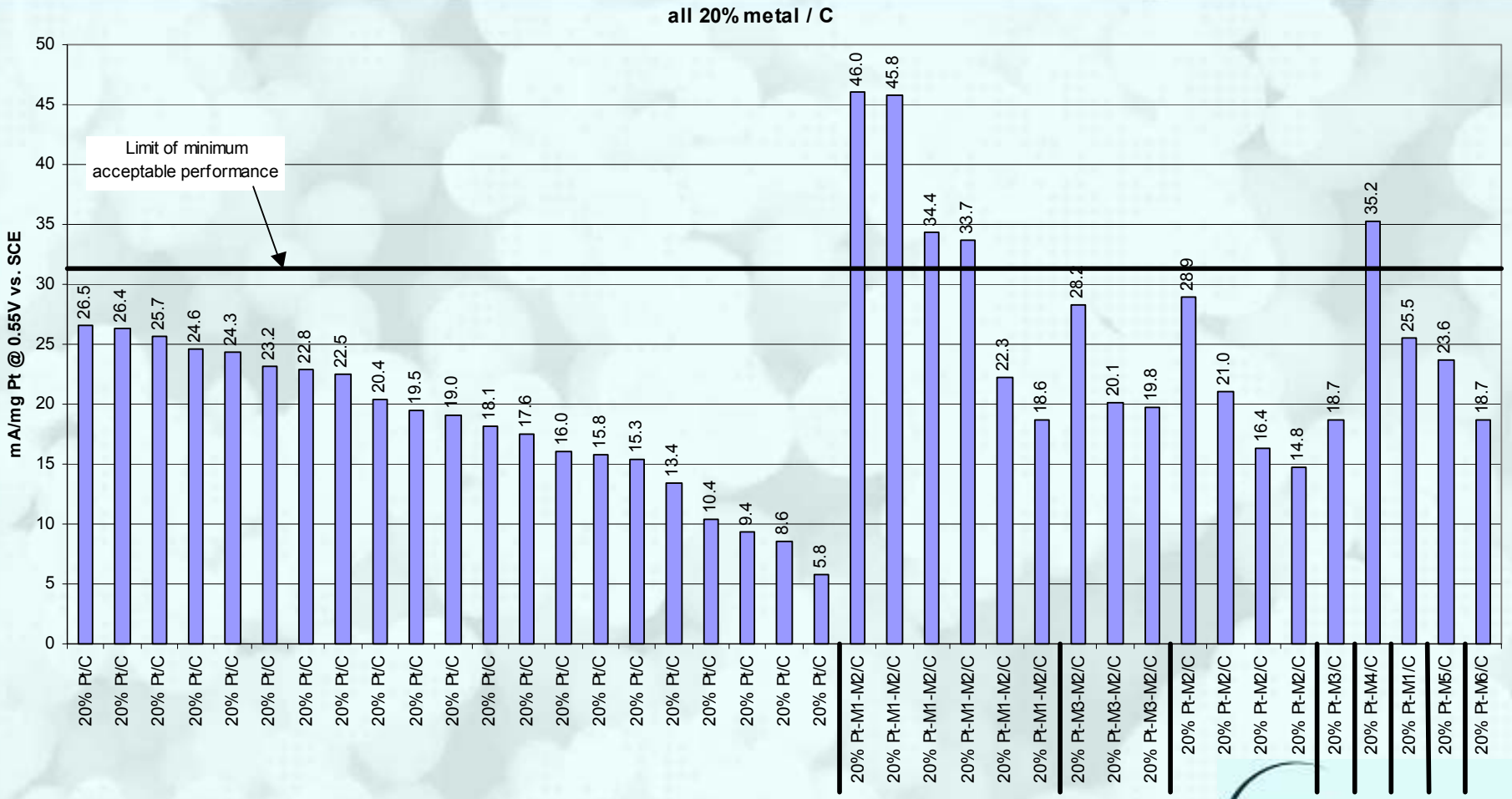
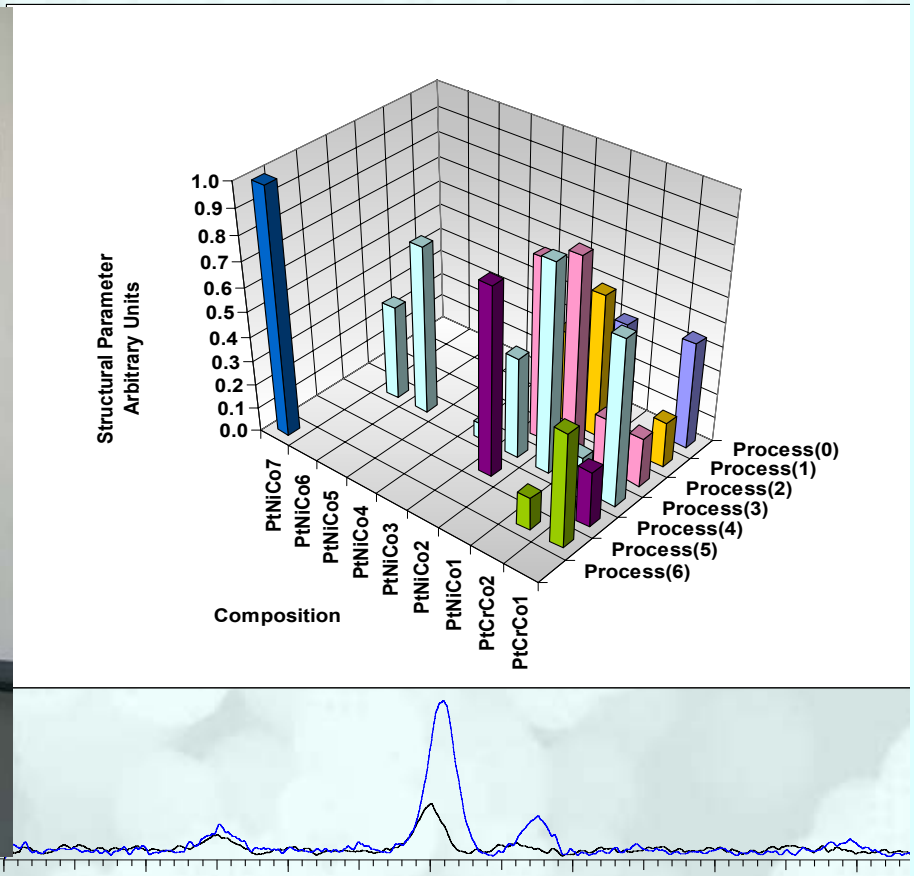
Summary of Achievements Effort 1
Milestone 5: High Throughput Screening



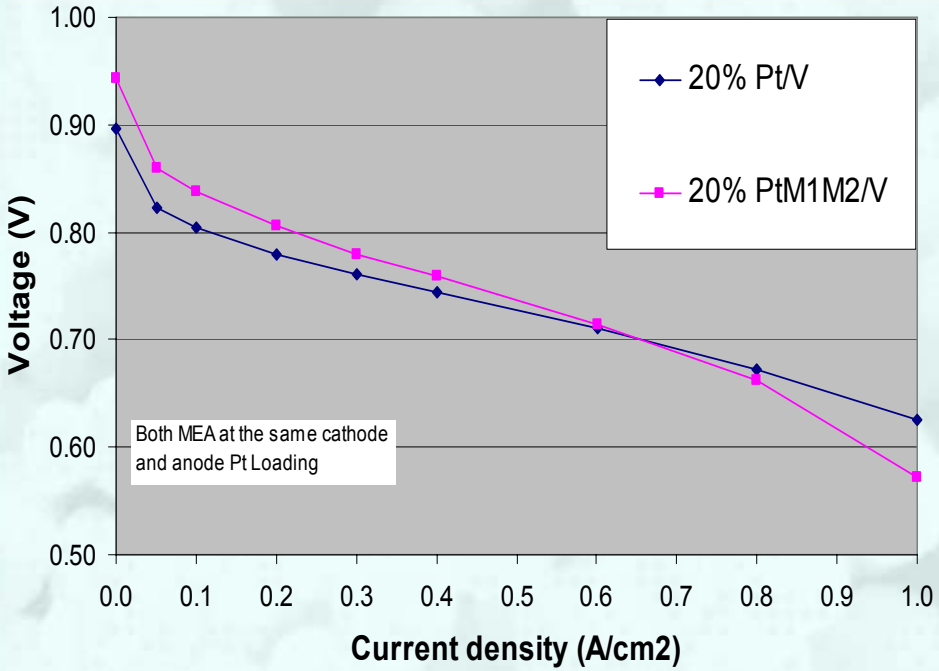
Characterization of Pt-alloy Electrocatalysts

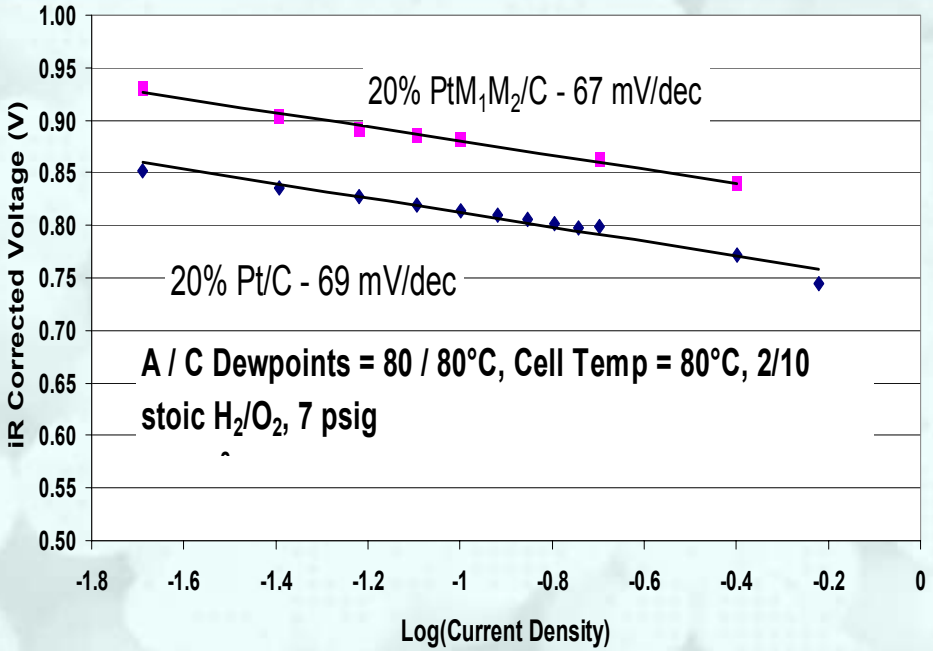


20 wt.% $Pt_xNi_yCo_z/C$

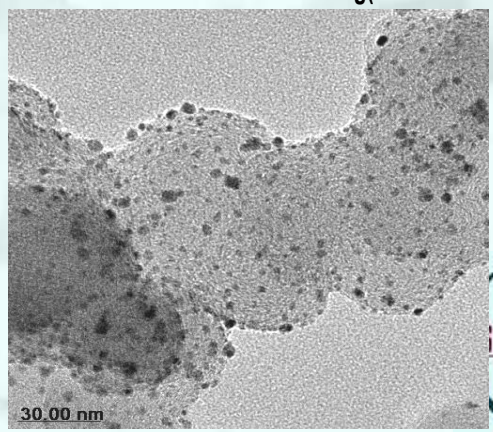
- *Degree of alloying dependant on spray processing parameters and post-processing conditions*

Characterization of Pt-alloy Electrocatalysts





Single MEA Performance Data 80 C, 1.5H_2/2.5air at 1A/cm², 100% RH, 30 psig, 15 min/point



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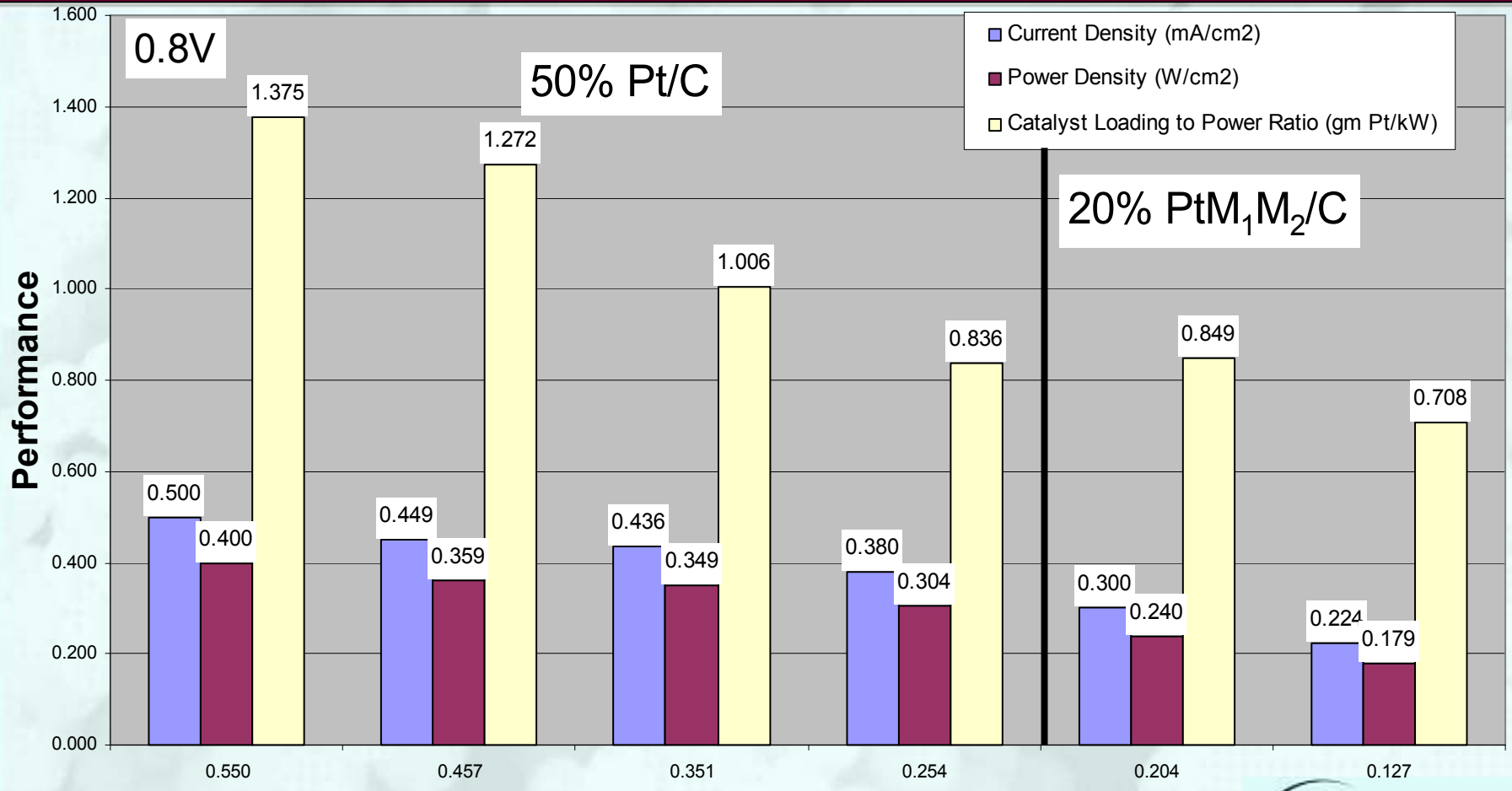
Summary of Achievements Effort 2
MEA Structure Optimization



Single MEA Performance Data
80 C, 1.5H$_2$/2.5air at 1A/cm^2, 100% RH, 30 psig, 15 min/point

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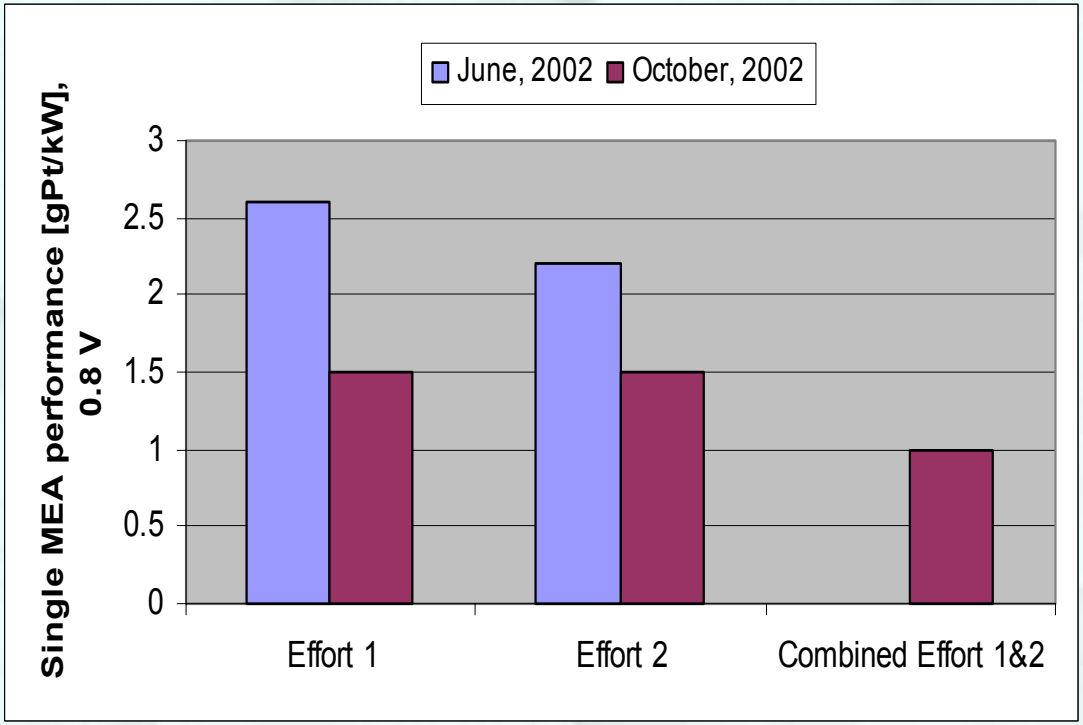
Significant Interactions

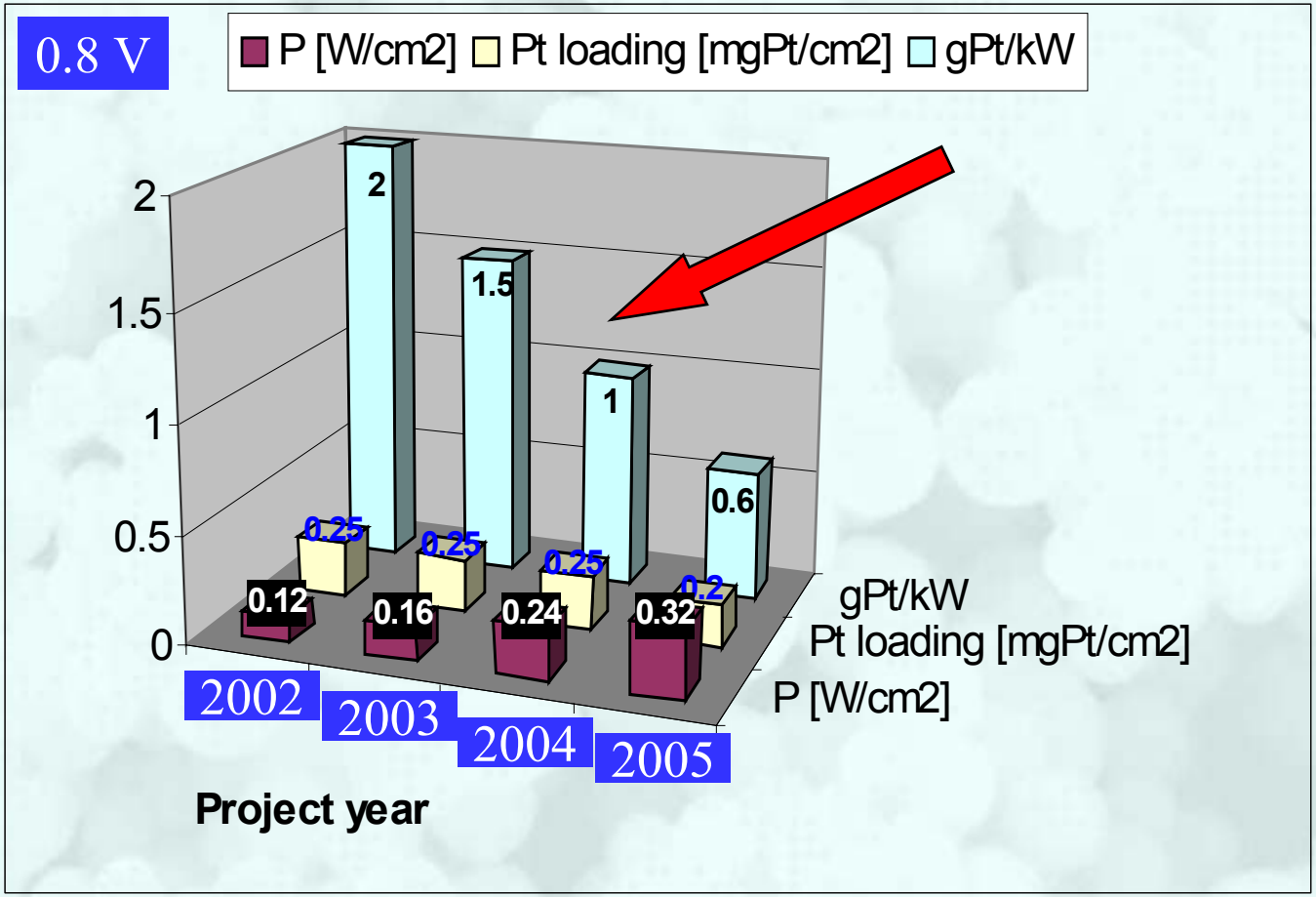
- ***Los Alamos National Laboratory***
  - » Knowledge/experience transfer for alloy ORR catalysts
  - » Pt alloys characterization by XRD (Fernando Garzon)
  - » Validation testing (Francisco Uribe)
- ***General Motors, Fuel Cell Activities***
  - » Testing criteria (Hubert Gasteiger)
  - » Validation testing (Susan Yan)
- ***Other Fuel Cell Developers***

Summary of Achievements Combined Effort 1 and Effort 2



- **Effort 1:** Ternary alloy catalyst performance improved from 2.6 gPt/kW to <1.5 gPt/kW
- **Effort 2:** MEA structure development yields improvement from 2.2 gPt/kW to <1.5 gPt/kW
- Combined best alloy catalyst and best MEA structure result in performance of <1 gPt/kW

Status vs. Project Performance Targets



- *Currently in a single MEA 50 cm^2 test cell, Nafion 112*
- *Testing at fixed lower stoich conditions*
- *Need to validate results in stack*
- *Need to address long term stability*
- *Further improvements can be derived also from a thinner membrane*

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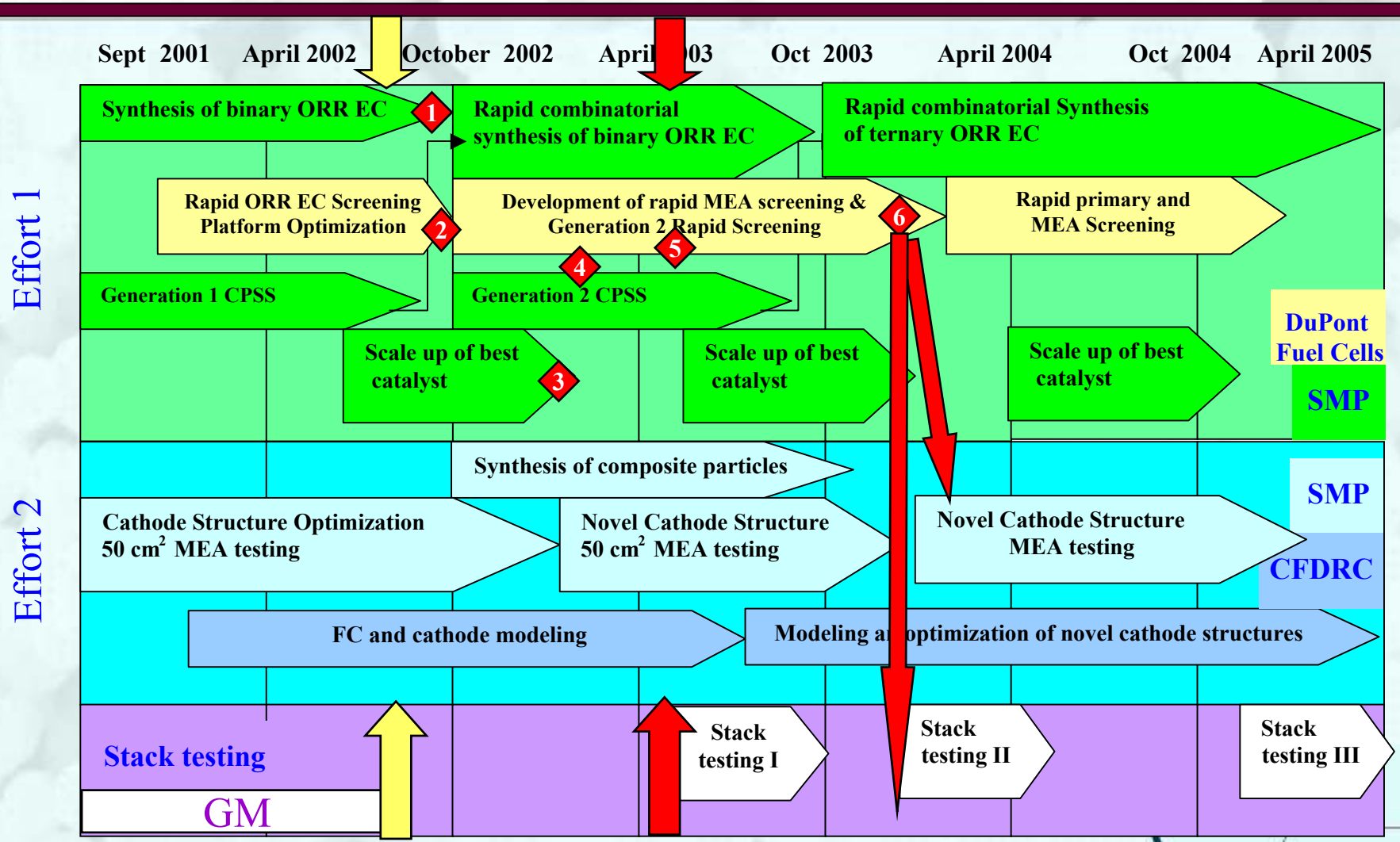
Plans and Future Milestones



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- *SMP, DuPont Fuel Cells and CFDRC for cost share funding*
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- *DuPont Fuel Cells: JoAnn Schwartz, Lin Wang,Keith Tomey, John Gantzhorn, Richard Okine*
- *CFDRC: Sandip Mazumder, Sam Lowry*

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