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Combinatorial Spray-Based Synthesis of PEM FC Electrocatalysts

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Cabot Superior MicroPowders, USA

Content



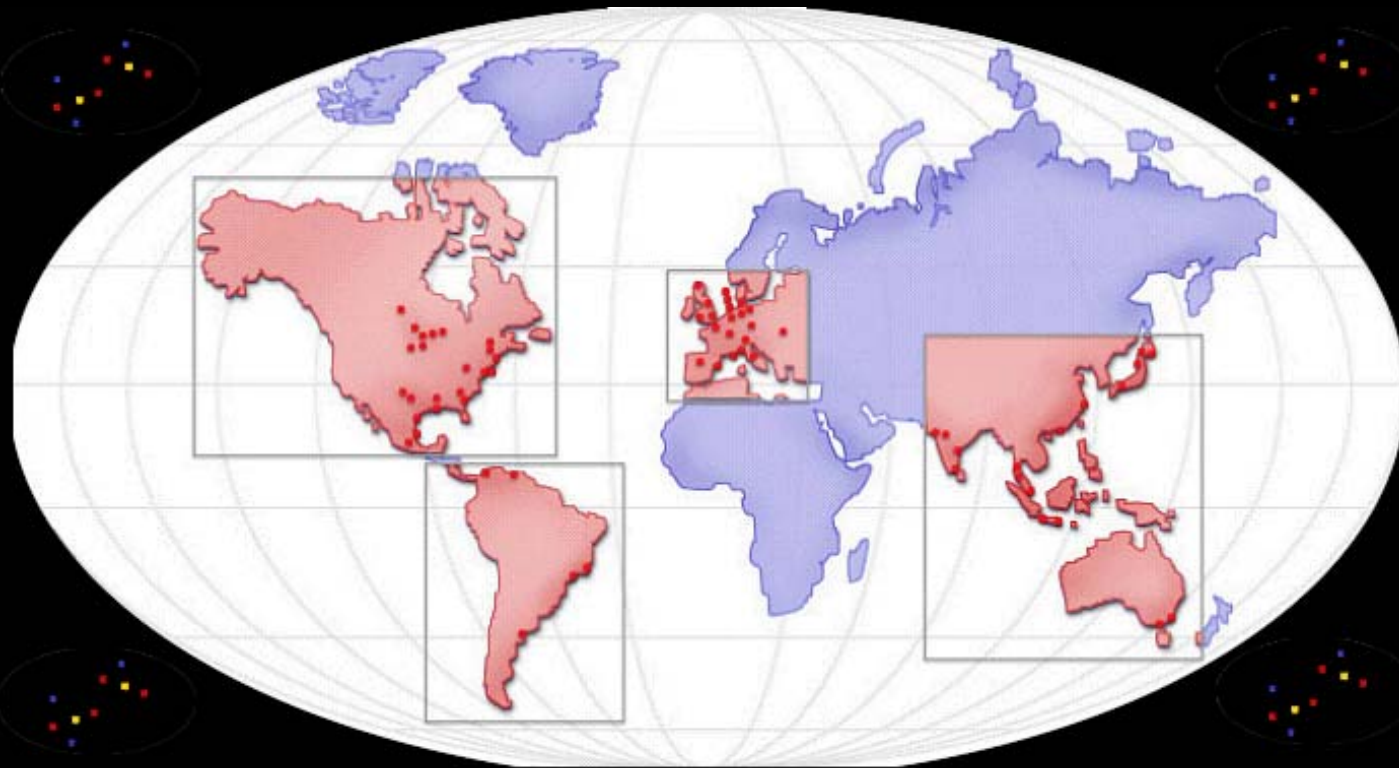
- **Superior MicroPowders Now a Division of Cabot Corporation**
- **CSMP Powder Production Process**
- **Combinatorial Spray-Based Synthesis of Binary and Ternary Alloys**
- **Conclusions and Path Forward**

Cabot is a Global Company



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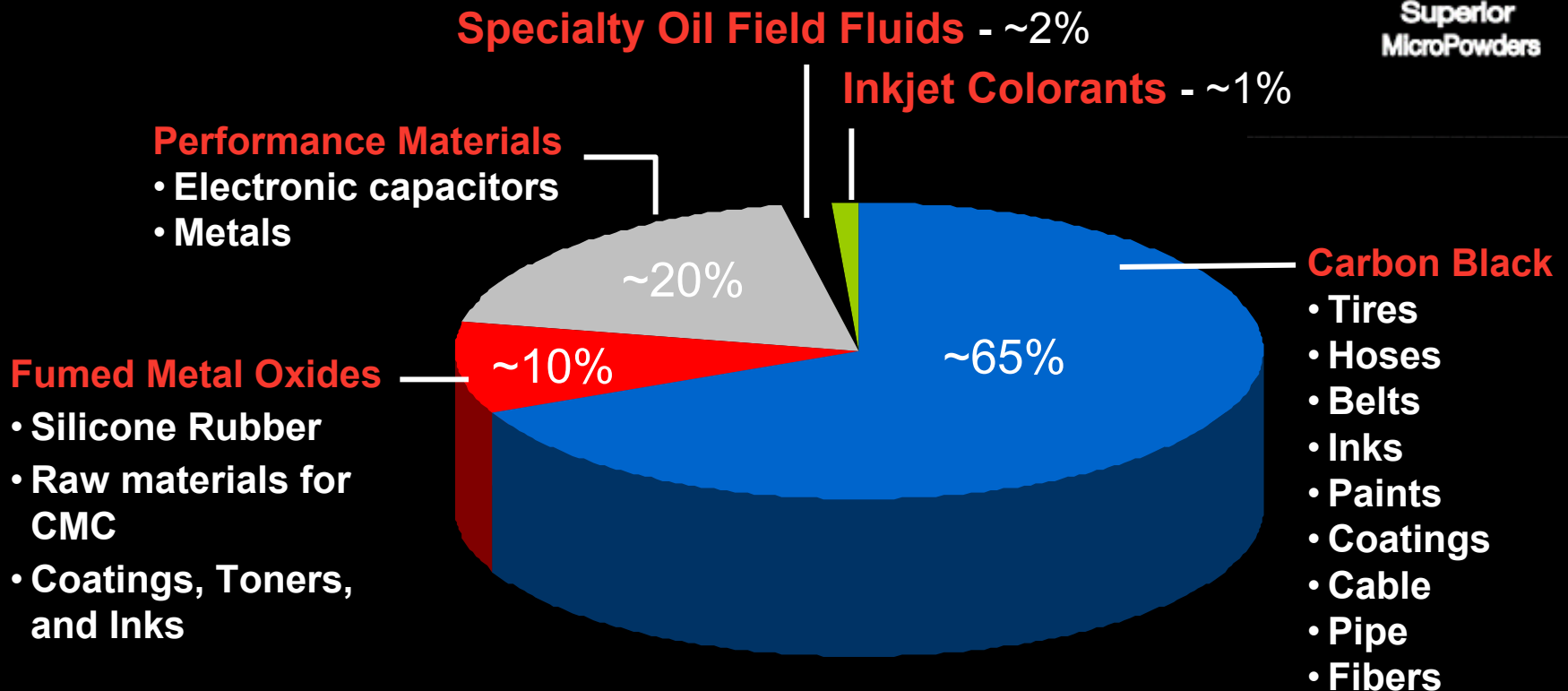


4,200 employees in 27 countries and 40 sites

Cabot Businesses



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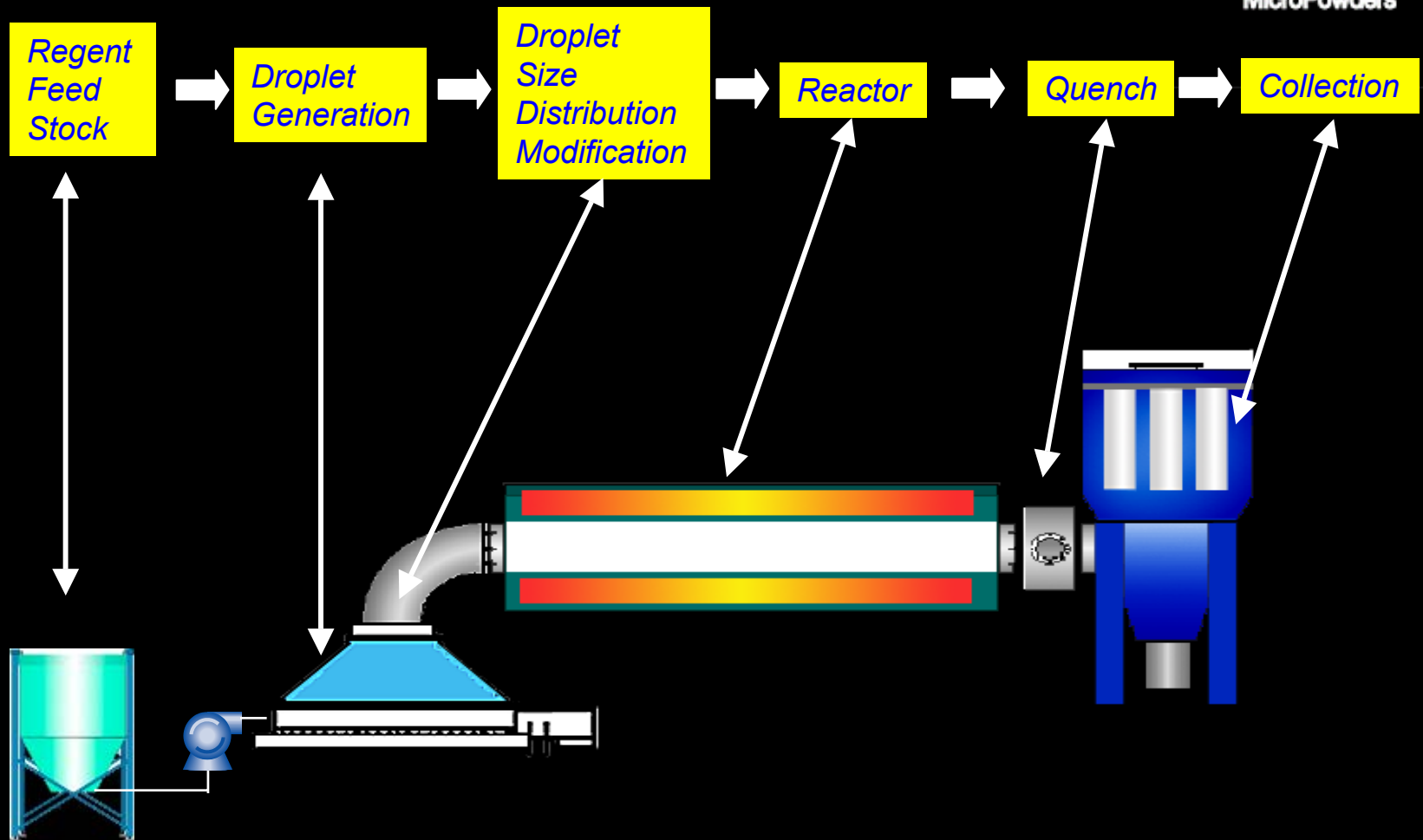


Total Sales in 2002 = \$1.6 billion

Process Components



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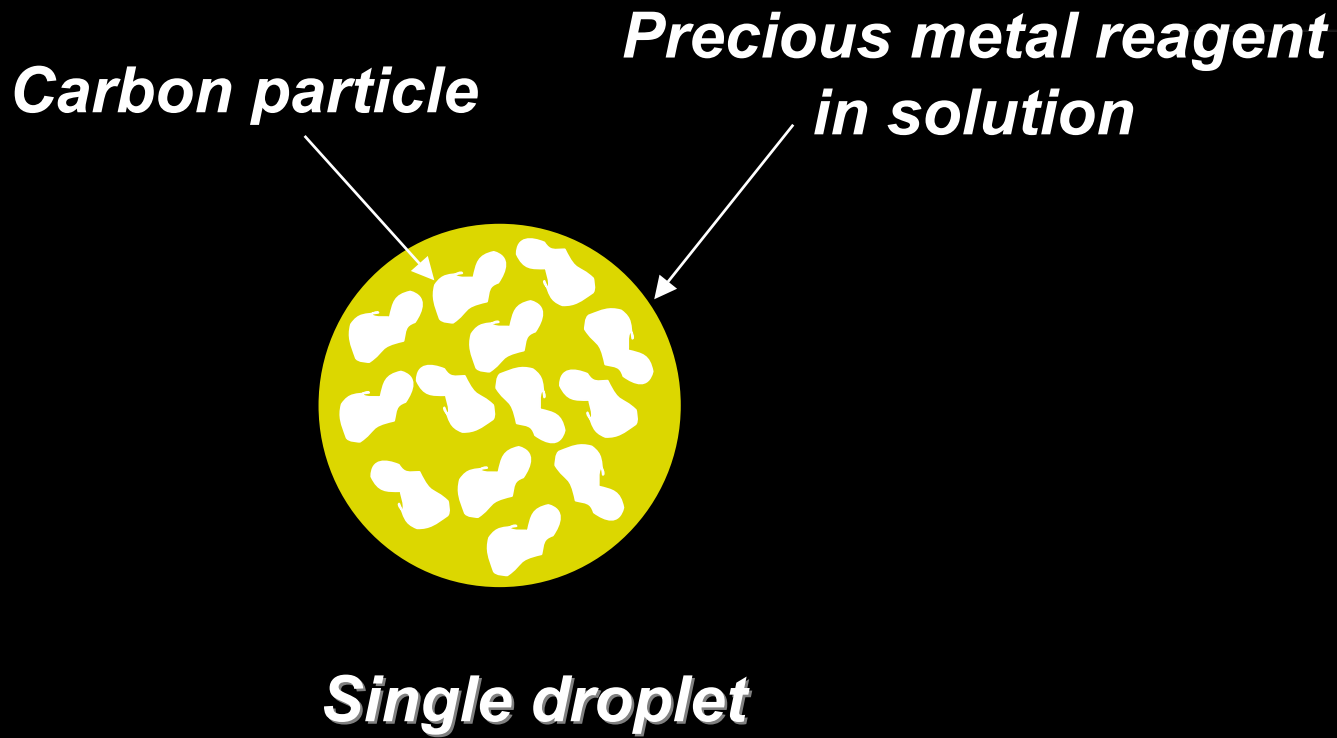


Process Simplicity

~ Feedstock Droplet ~



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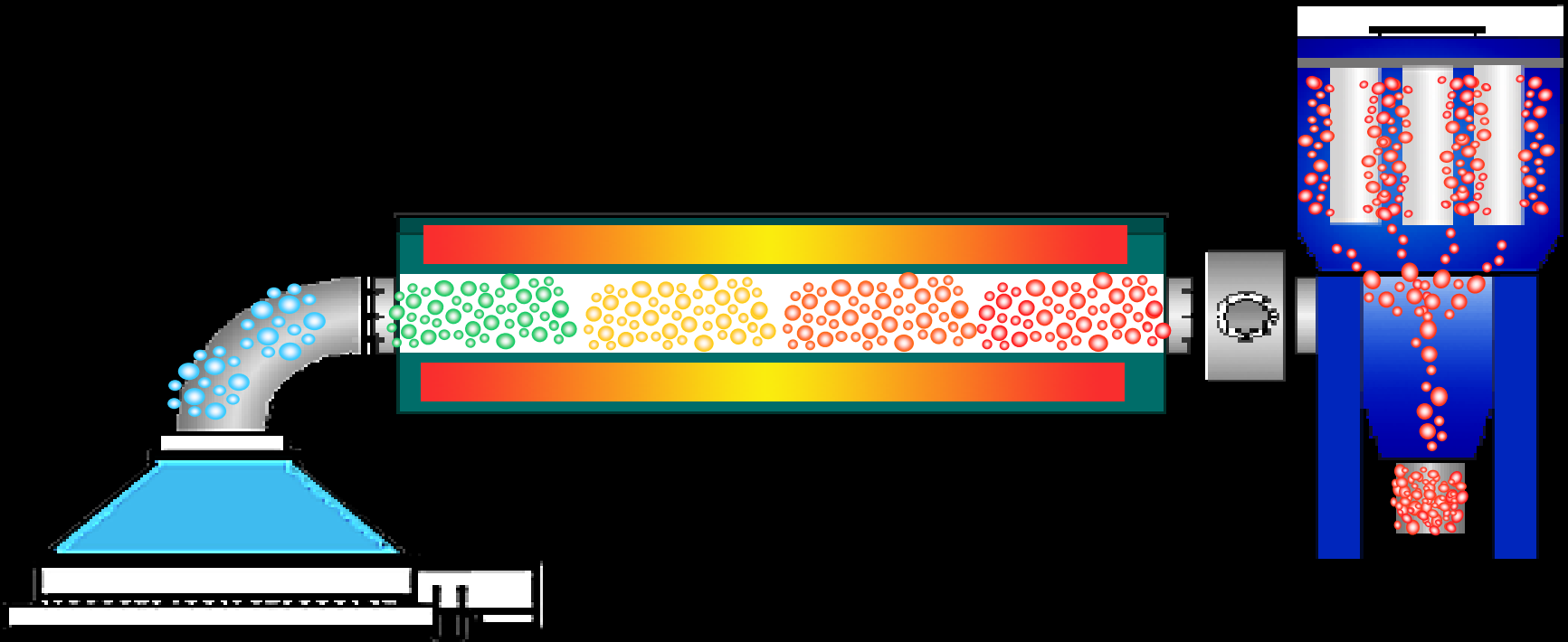


Process Operation



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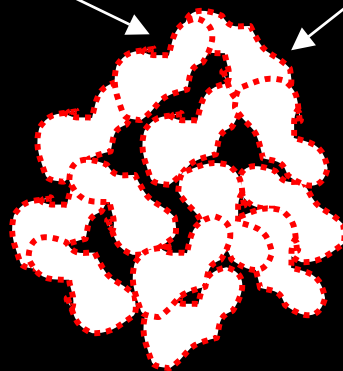
Final Product



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*Precious metal
nanoparticle*

Carbon nanoparticle



*Electrocatalyst
aggregate*

CSMP Electrocatalyst Powders



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- Standard *Dynalyst*TM Electrocatalysts

Cathode		Anode	Carbon Supports
10% Pt/C	20% Pt/C	40% PtRu/C	Shawinigan black
30% Pt/C	40% Pt/C	60% PtRu/C	Vulcan [®] XC-72
50% Pt/C	60% Pt/C		Ketjen black
MnO _x /C			

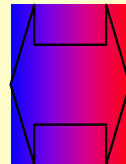
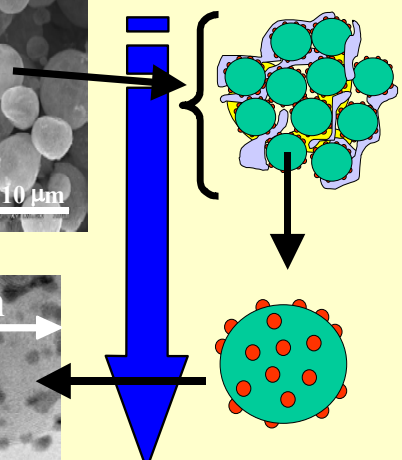
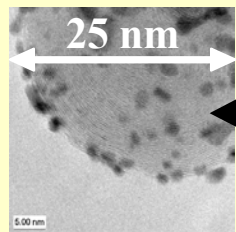
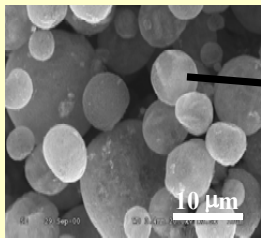
Development of High-Performance, Low-Pt Cathodes Containing New Catalysts and Layer Structure



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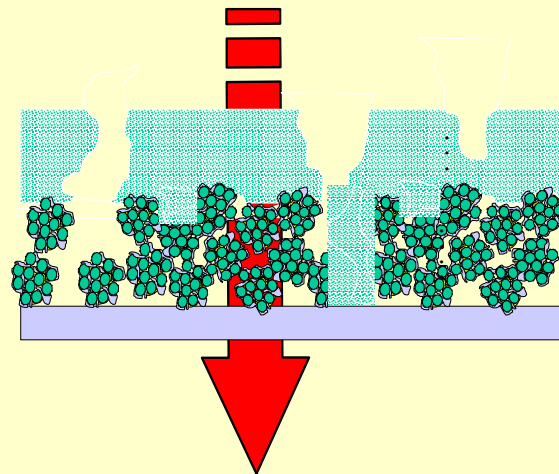
Effort 1

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:
 - CSMP
 - DuPont Fuel Cells
- Effort 2:
 - CSMP
 - CFDR
- Short Stack Testing:
 - GM
 - Partnerships

Combinatorial Discovery of New Compositions & Microstructures

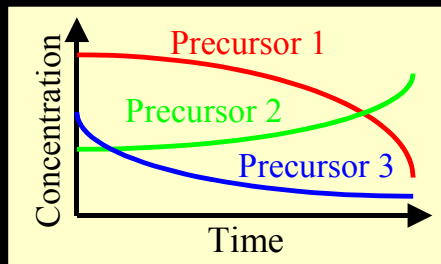


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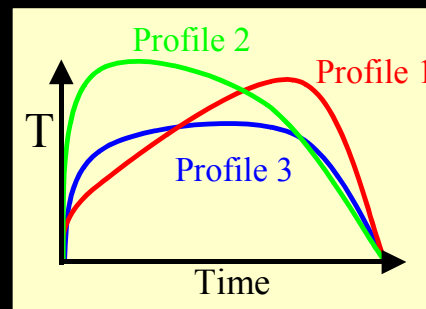
- Compositional variability
- Microstructural variability
- Discovery on commercially scaled platform



Composition



Microstructure

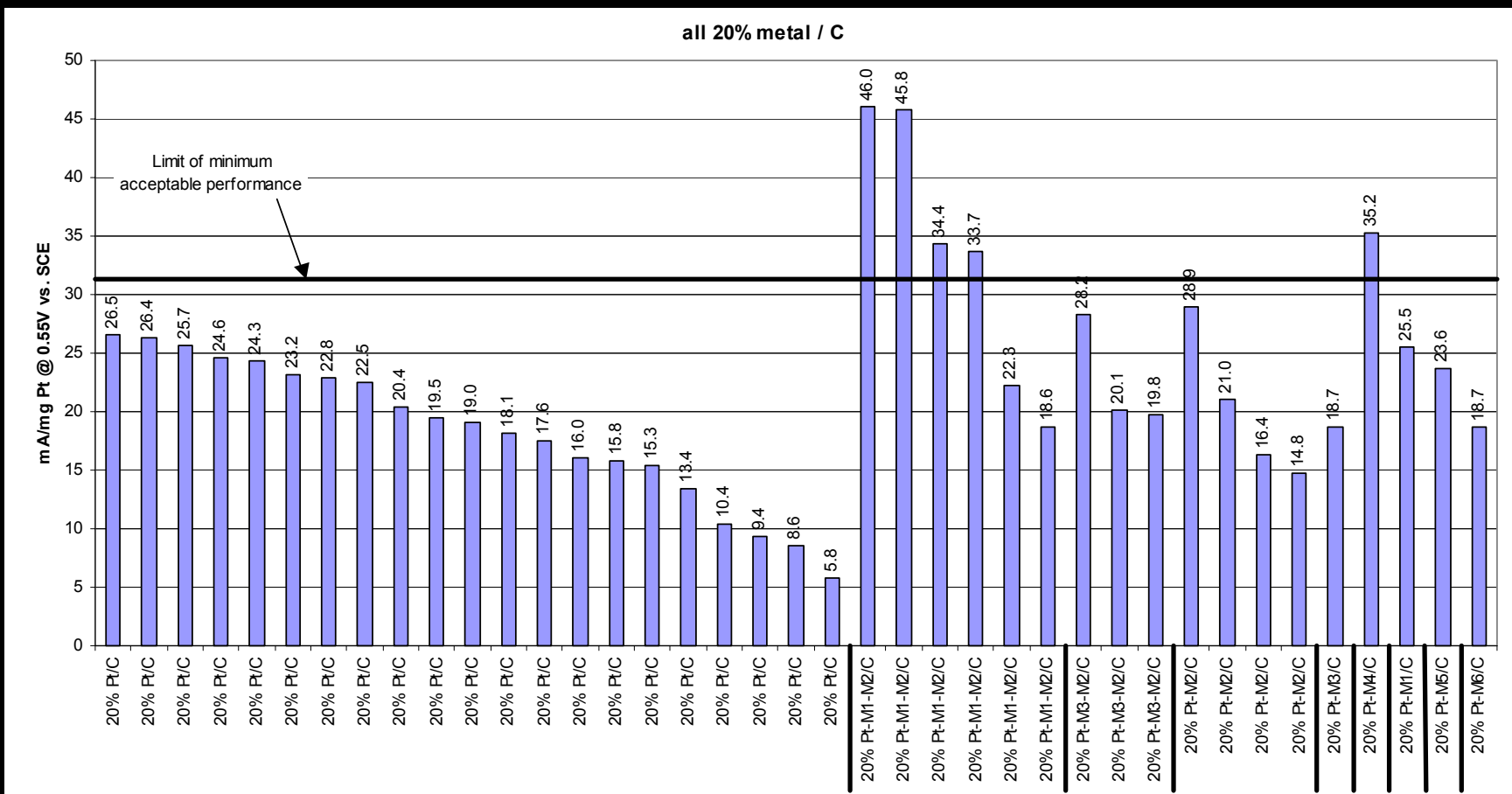


Selection of Composition and Structure Targets



- **Cost of components** - raw materials, precursor cost
- **Cost of manufacturing** (precursors, processing steps) - fabrication cost
- **Demonstrated performance advantage** or possible one based on established general trends
- **Long term stability**
 - stable in acidic media/resistant to corrosion
 - sustainable performance at high potentials
 - sustainable dispersion of the active phase

High Throughput Screening Data for CSMP Electrocatalysts

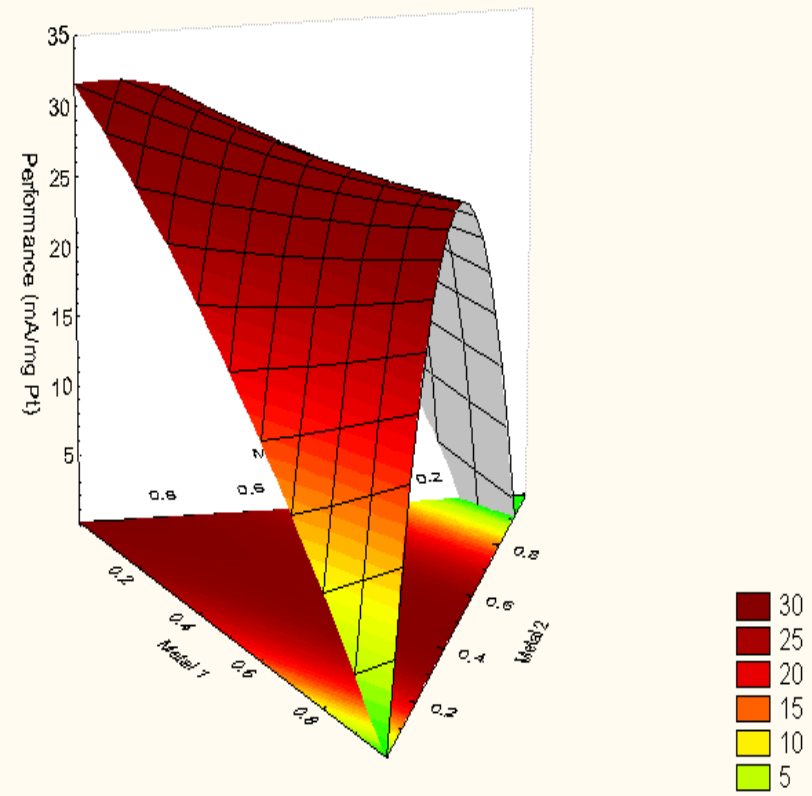
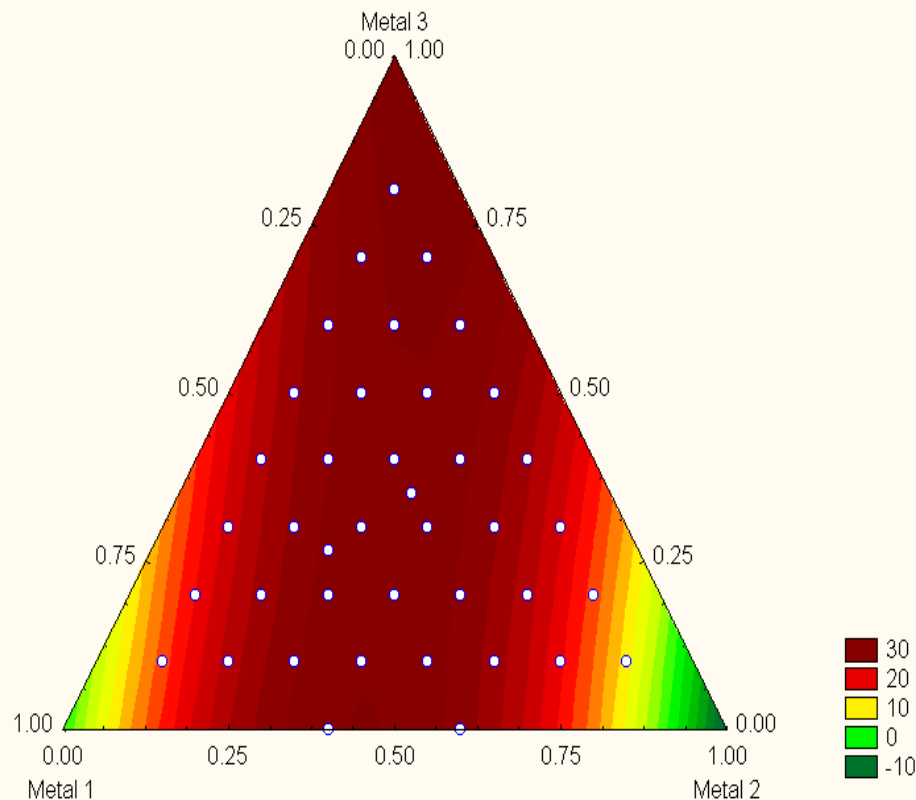


High Throughput Data – Performance Maps of Alloys

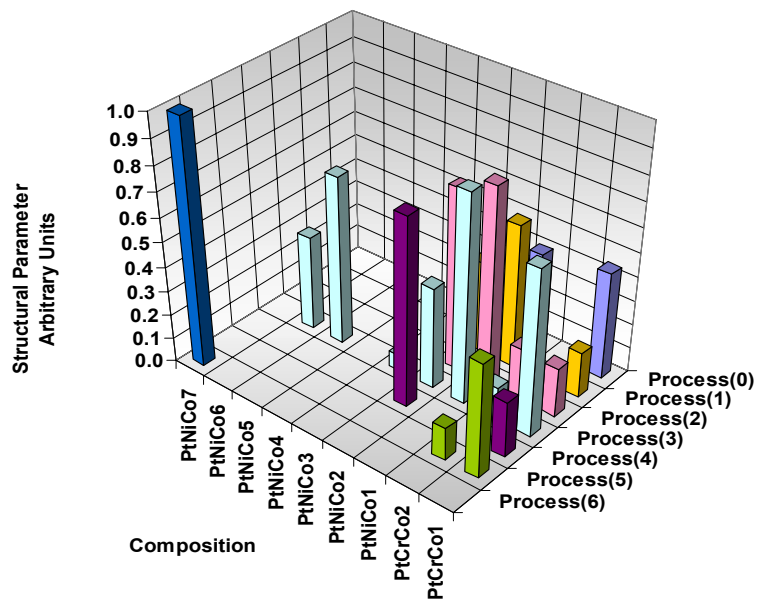


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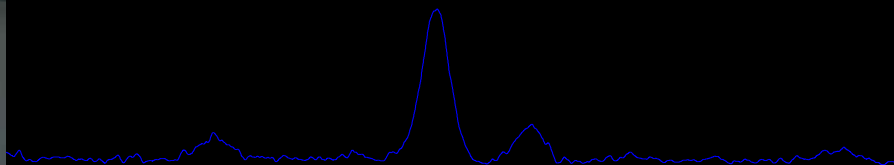
Performance Map Of a Ternary Alloy



Characterization of Pt-alloy Electro-catalysts



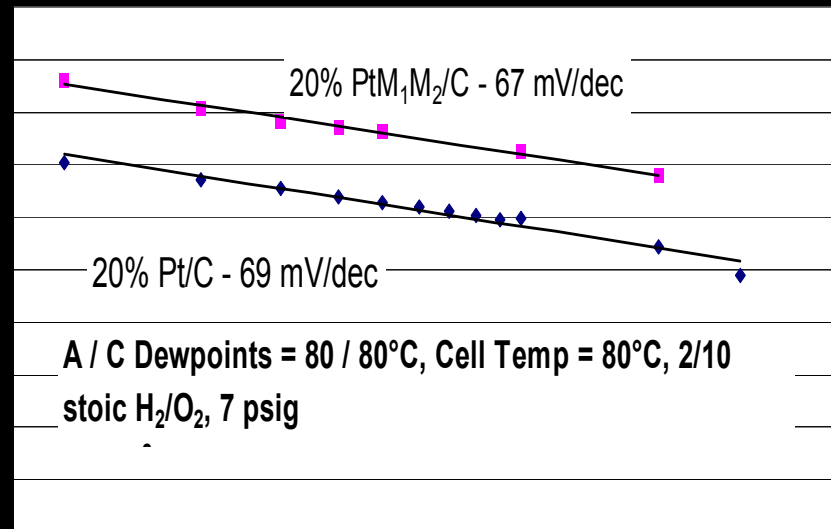
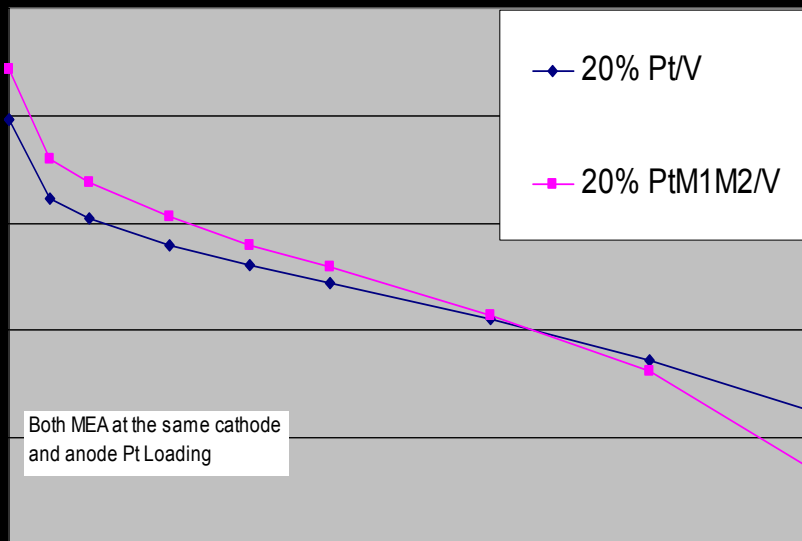
- Degree of alloying dependent on spray processing parameters and post-processing conditions



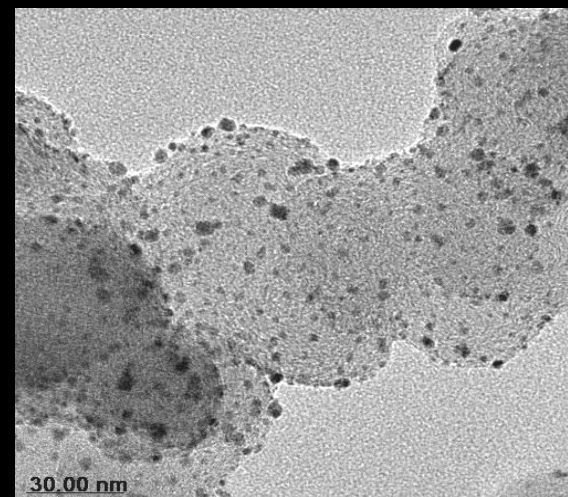
Characterization of Pt-alloy Electro catalysts



Voltage (V)



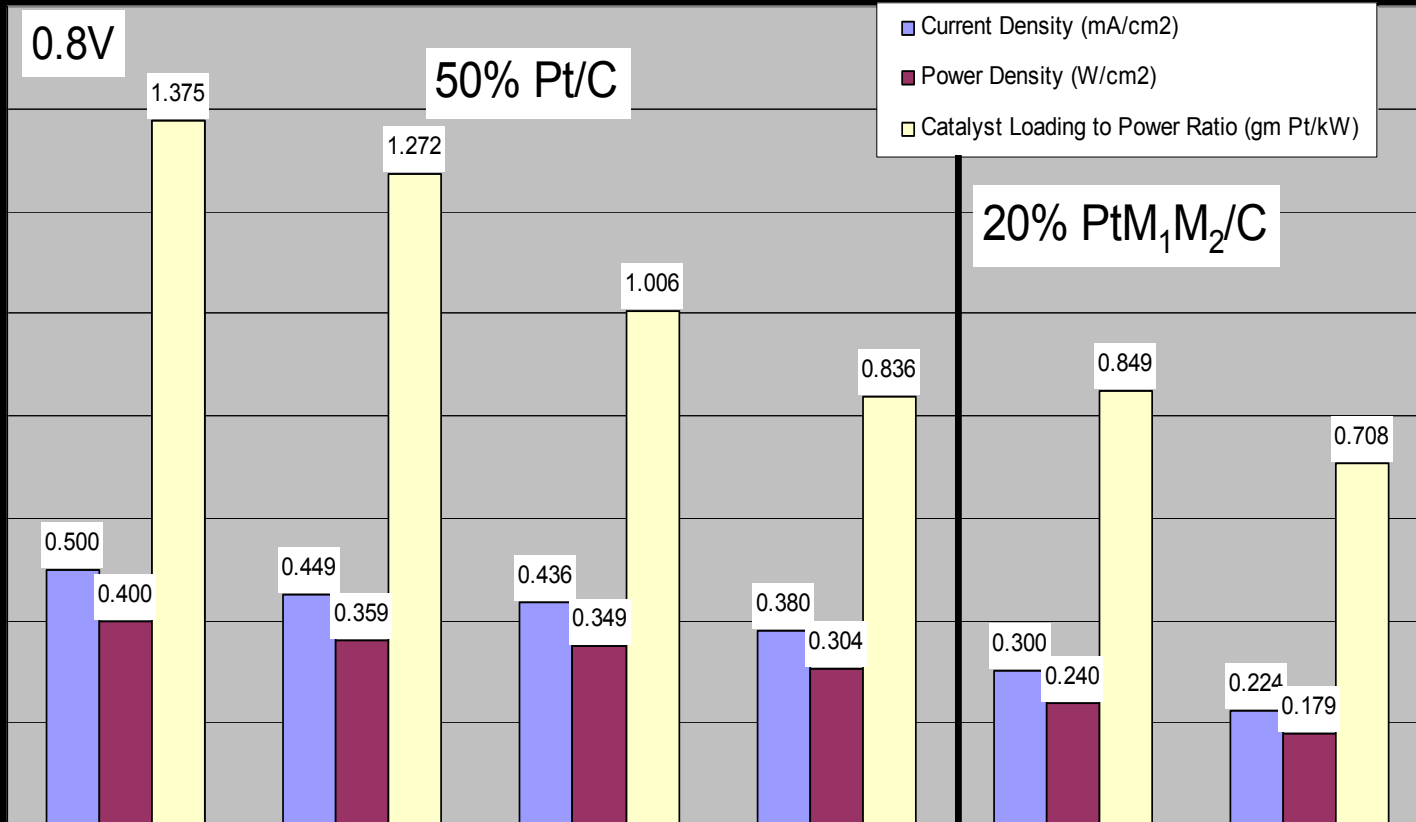
***Single 50 cm² MEA Performance
80 C, 1.5H₂/2.5air at 1A/cm²,
100% RH, 30 psig, 15 min/point***



MEA Structure Optimization



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Single 50 cm² MEA Performance Data
80 C, 1.5H₂/2.5air at 1A/cm², 100% RH, 30 psig, 15 min/point

Performance

Electrocatalyst Scale Up



Production
1,000's Kg
range

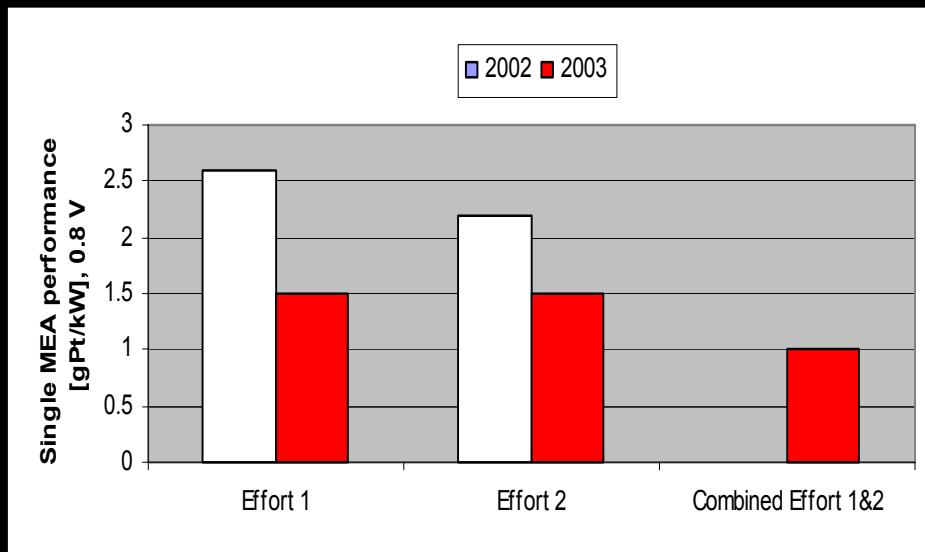
Combinatorial
100 mg range



Combined Effort 1 and Effort 2 Status vs. Performance Targets



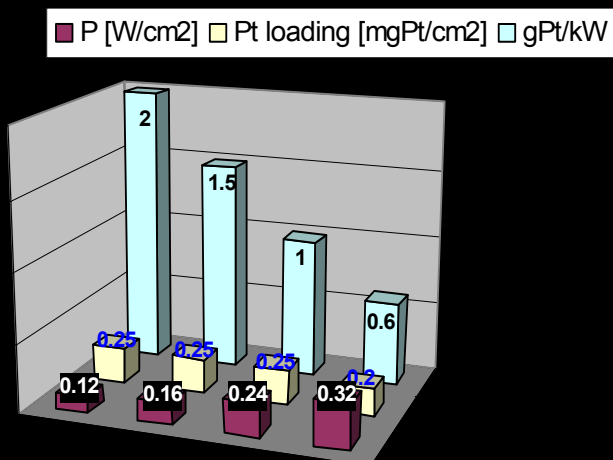
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- **Effort 1:** Ternary alloy catalyst performance improved from 2.6 gPt/kW to <1.5 gPt/kW

- **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**



Summary and Path Forward



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- **Spray-Based Combinatorial Powder Synthesis System Completed**
- **Successful Synthesis of Alloy Composition Demonstrated and Scaled up**
- **Screening of Large Number of Compositions in Progress**
- **Strong Emphasis on Long Term Stability of Electrocatalysts**
 - **Stability in acidic media**
 - **Stability to active phase agglomeration**
- **Rapid testing in MEA configuration**
- **Testing in Stacks**

Acknowledgements



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MicroPowders

- DOE OTT, Award DE-FC0402AL67620,
- DOE Program Manager: Valri Lightner
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- DuPont Fuel Cells: JoAnn Schwartz, Lin Wang, Keith Tomey, Richard Okine