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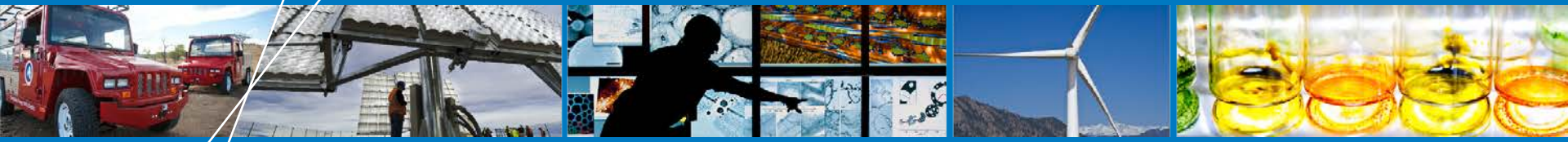
High Aspect Ratio Nano-Structured Pt-based PEM Fuel Cell Catalysts



DOE Hydrogen and Fuel Cells Program Review 2012

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Project ID: FC100

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Start – December 2011
- Finish – December 2013
- 20% complete

Barriers

- Cost (Catalyst/MEA)
- Performance (Catalyst/MEA)

Budget

- Total project funding: $113,200
- DOE FY11 Funding: $113,200

Relevance

Objective

- **Produce novel high aspect ratio nano-structured Pt-based catalyst materials with increased activity and increased Pt utilization, moving towards meeting all 2015 DOE catalyst targets**

Table 3.4.12 Technical Targets: Electrocatalysts for Transportation Applications

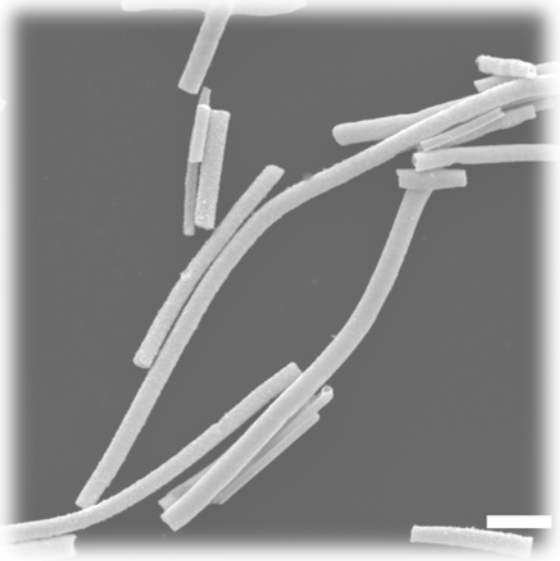
Characteristic	Units	2005 Status [a]		Stack Targets	
		Cell	Stack	2010	2015
Platinum group metal total content (both electrodes)	g / kW (rated)	0.6	1.1	0.3	0.2
Platinum group metal (pgm) total loading [b]	mg PGM / cm^2 electrode area	0.45	0.8	0.3	0.2
Cost	$ / kW	9	55 [c]	5 [d]	3 [d]
Durability with cycling					
Operating temp ≤80°C	hours	>2,000	~2,000 [e]	5,000 [f]	5,000 [f]
Operating temp >80°C	hours	N/A [g]	N/A [g]	2,000	5,000 [f]
Electrochemical area loss [h]	%	90	90	<40	<40
Electrocatalyst support loss [h]	mV after 100 hours @ 1.2V	>30 [i]	N/A	<30	<30
Mass activity [j]	A / mg Pt @ 900 $mV_{iR\text{-}free}$	0.28	0.11	0.44	0.44
Specific activity [j]	μA / cm^2 @ 900 $mV_{iR\text{-}free}$	550	180	720	720
Non-Pt catalyst activity per volume of supported catalyst	A / cm^3 @ 800 $mV_{IR\text{-}free}$	8	N/A	>130	300

Approach

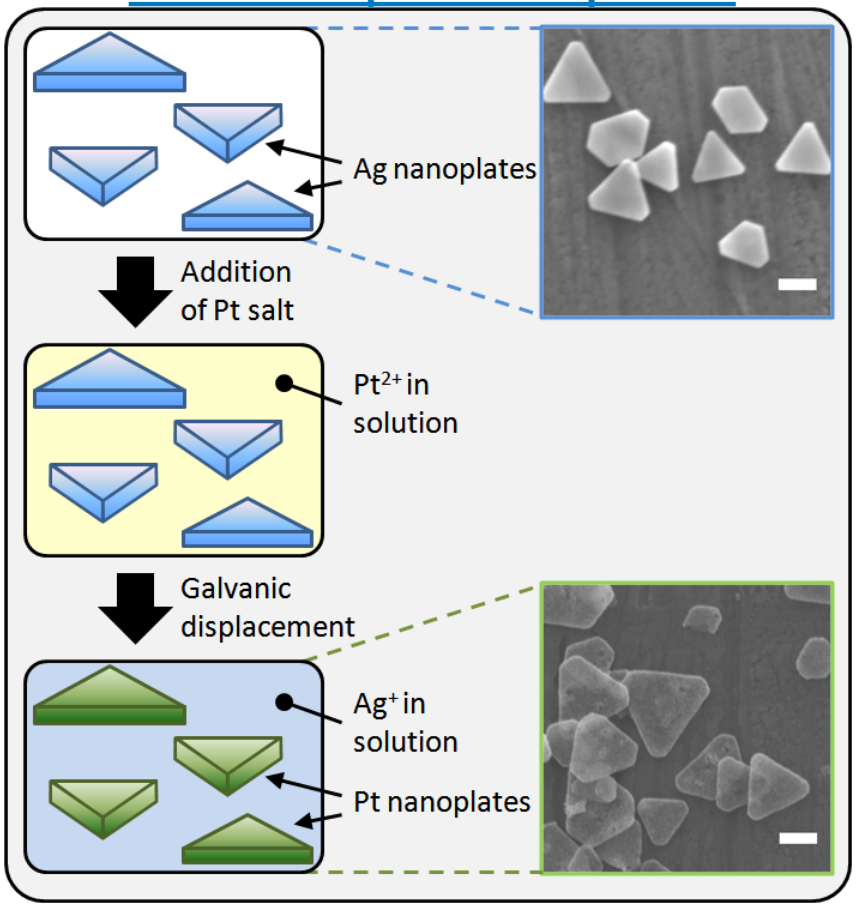
Synthesis of Extended Thin-Film Electrocatalyst Structures: ETFECS

- **Galvanic displacement of controlled shape nanomaterials**
- **Control of galvanic displacement reactions can allow tuning of catalyst morphology**

Pt nanotubes synthesized by galvanic displacement



Galvanic displacement process

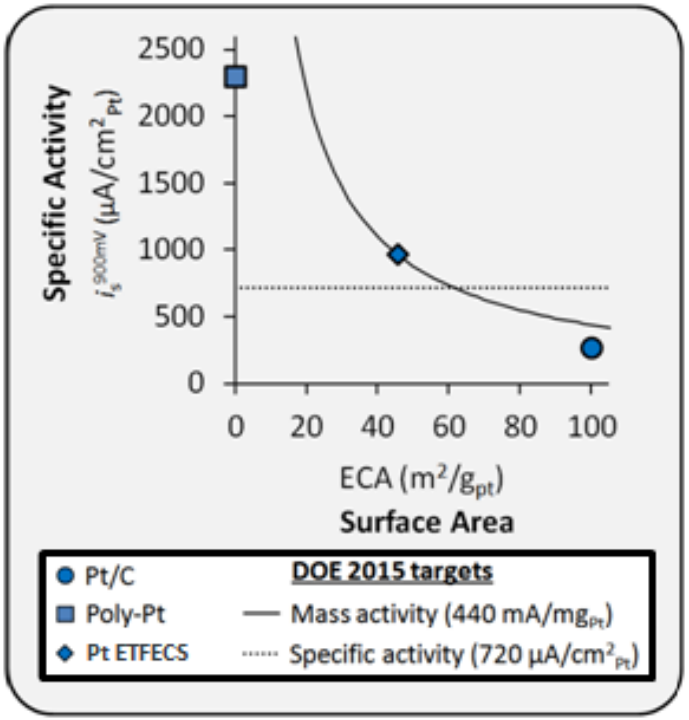


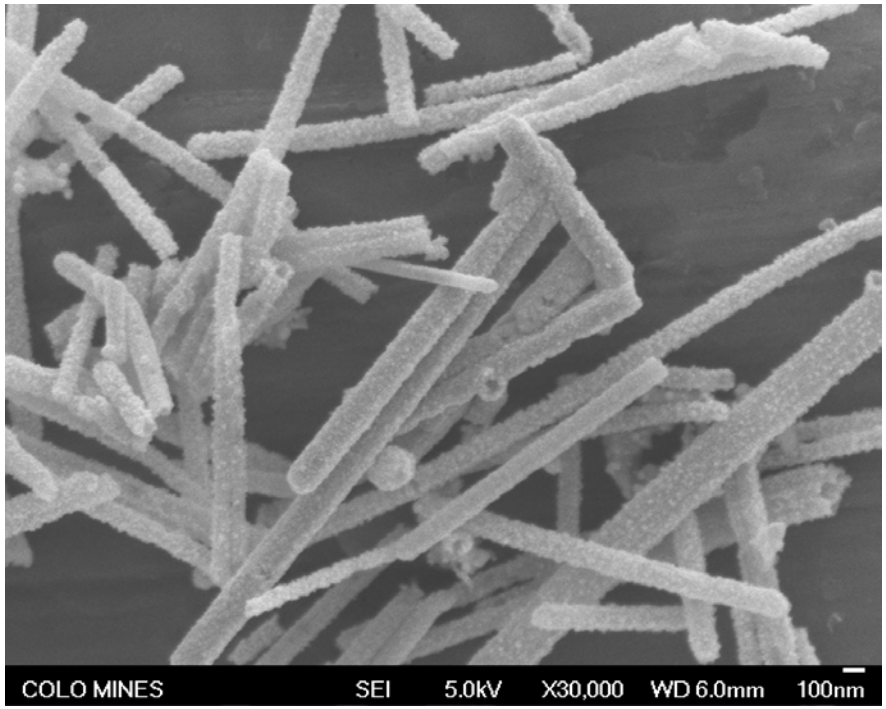
*Scale bars are 1 micron

Accomplishments and Progress

Synthesis of Pt nanotube

- Ag used as template materials
- High specific activity for both materials (>1000 $\mu A/cm^2_{Pt}$)
- Pt nanotubes achieved 450 mA/mg Pt in RDE half-cell testing
- Synthesized in gram scale quantities



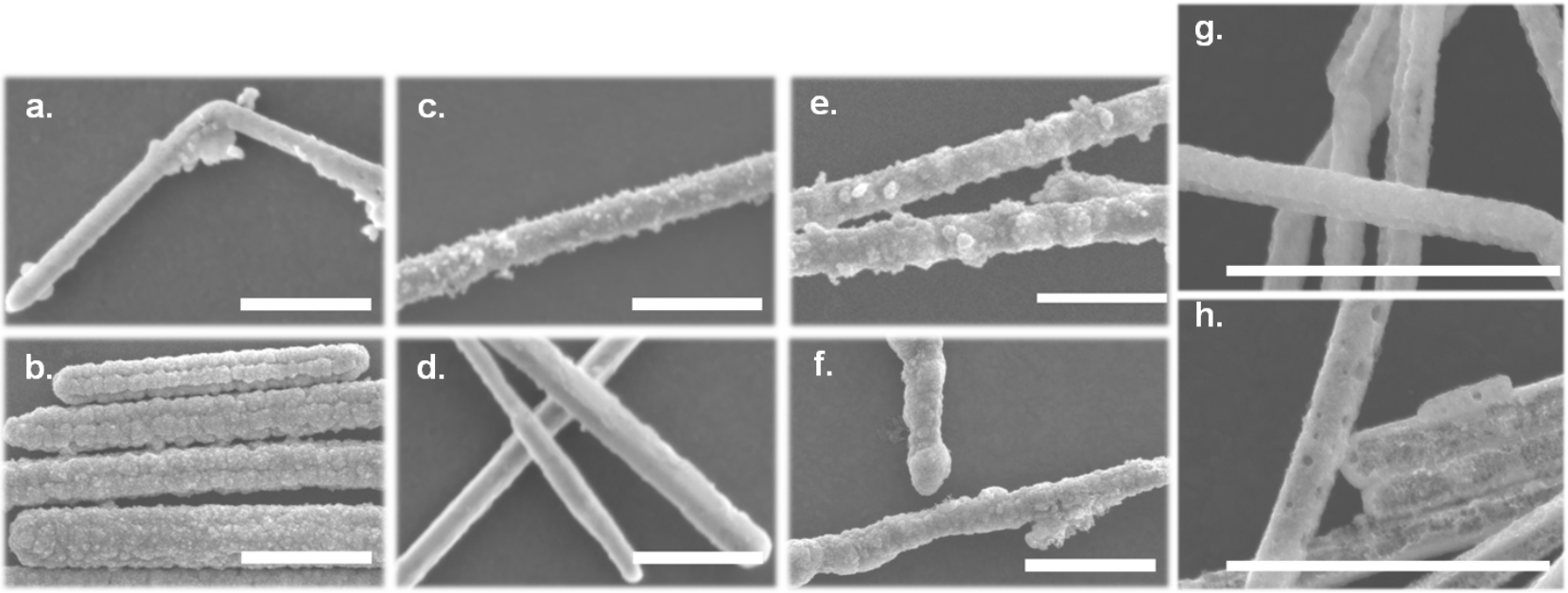


Accomplishments and Progress

Development of methods to tune

ETFECS surface area

- **Surface ligand effects**
- **Control of surface deposition**
- **>45 m2 per gram achieved**

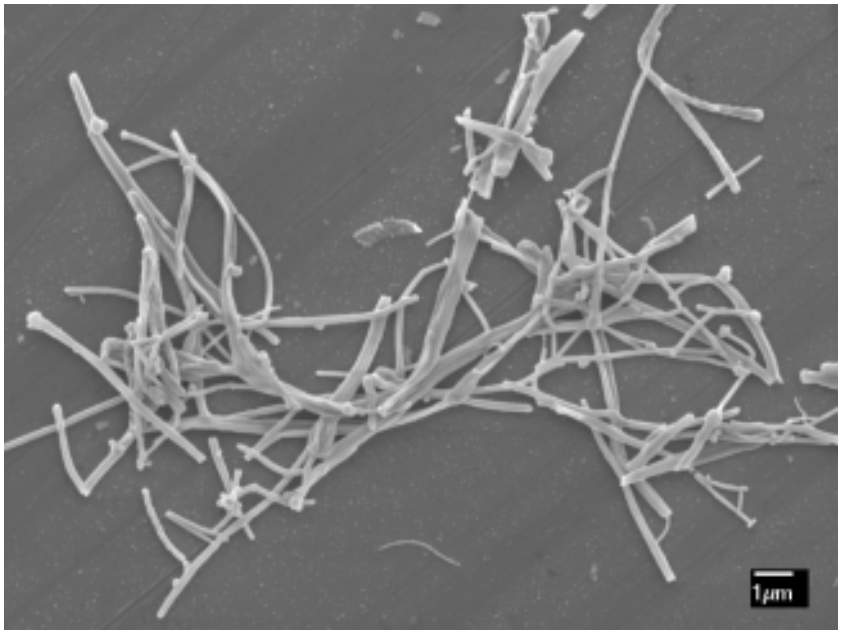


The surface morphology of materials synthesized by galvanic displacement may be controlled by several parameters, such as utilizing surface ligands with different binding affinities (alkanoic acids [a, b], alkylamines [c, d], and alkanethiols [e, f]) or disrupting conformal deposition on the template surface (g and h).

Proposed future work

Exploration of new Pt-alloy ETFECS materials, including Cu, Ni, and Co

Initial synthesis results of PtCu ETFECS materials



Pt_4Cu_6

Project Summary

Relevance:

Meeting all platinum-based electrocatalysts 2015 DOE technical targets for transportation applications.

Approach:

Synthesize ETFECS (Extended Thin Film ElectroCatalyst Structures) using galvanic displacement reactions.

Technical Accomplishments and Progress:

Synthesized gram-scale quantities of Pt ETFECS that have exceeded DOE 2015 mass activity target in RDE half-cell testing (450 mA/mg_{Pt}).

Proposed Future Research:

Explore new Pt-alloy ETFECS materials.

Acknowledgements

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