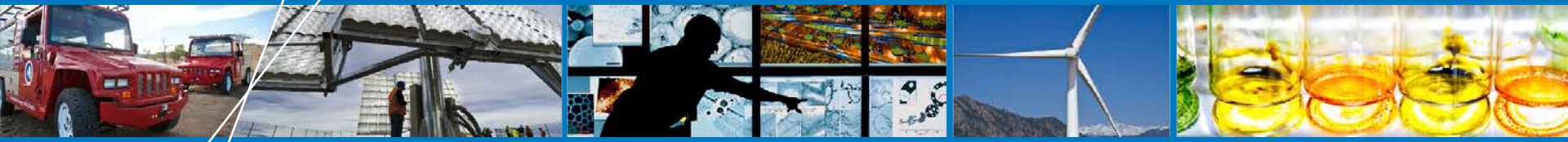
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

High aspect ratio fuel cell catalysts



2013 DOE Hydrogen and Fuel Cells Program Review

Brian A. Larsen, Ph.D.

5/16/2013

Overview

Timeline

- Project start date: 12/5/2011
- Project end date: 4/12/2013
- Percent complete: 100%

Budget

- $150,000 over FY12-13
- In-kind laboratory support from NREL

Barriers addressed

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

Relevance

Objective

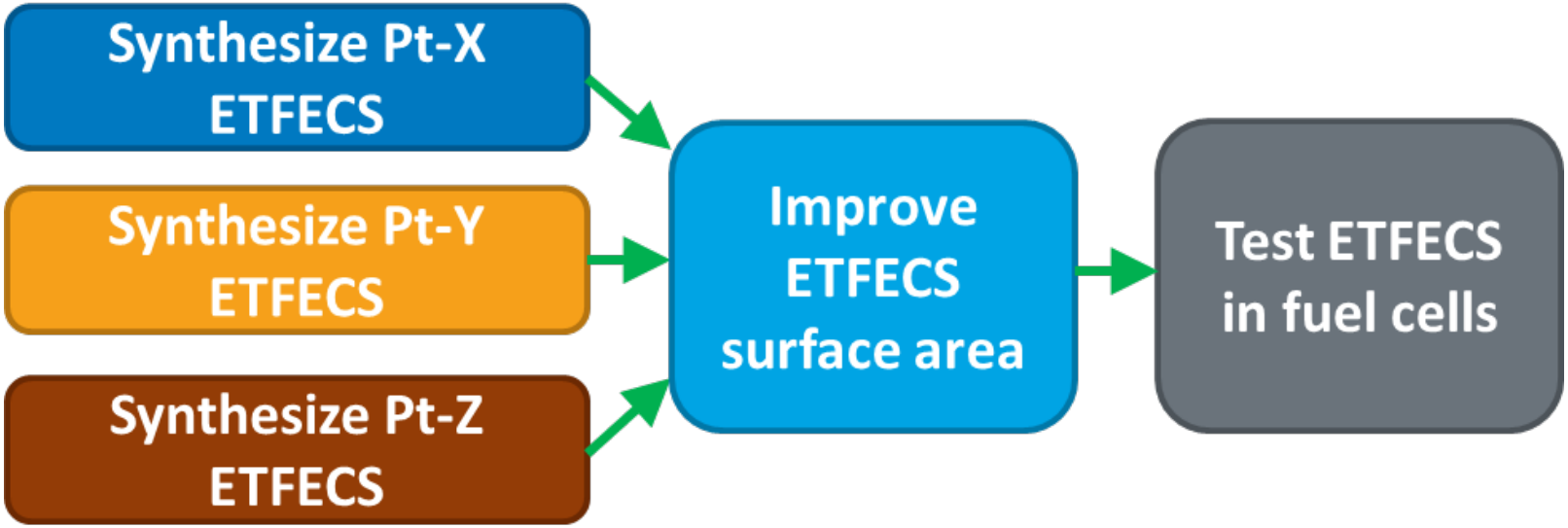
- **Produce novel high aspect ratio nano-structured Pt-based catalyst materials with increased activity and increased Pt utilization, moving towards meeting all 2017 DOE catalyst targets**

Table 3.4.13 Technical Targets: Electrocatalysts for Transportation Applications				
Characteristic	Units	2011 Status	Targets	
			2017	2020
Platinum group metal total content (both electrodes)[a]	g / kW (rated)	0.19[b]	0.125	0.125
Platinum group metal (pgm) total loading[a]	mg PGM / cm^2 electrode area	0.15[b]	0.125	0.125
Loss in initial catalytic activity[c]	% mass activity loss	48[b]	<40	<40
Electro catalyst support stability[d]	% mass activity loss	<10[b]	<10	<10
Mass activity[e]	A / mg Pt @ 900 $mV_{iR\text{-}free}$	0.24[b]	0.44	0.44

Approach

Synthesis of Pt Alloy Extended Thin-Film Electrocatalyst Structures: Pt Alloy ETFECS

- **Synthesis of Pt alloy ETFECS using 3 different alloying metals**
  - The objective of this activity is to maximize the Pt ETFECS specific activity
- **Development of methods to increase ETFECS surface area**
  - Increasing the surface area will increase the mass activity of the Pt ETFECS
- **Integrate and evaluate ETFECS in MEAs**

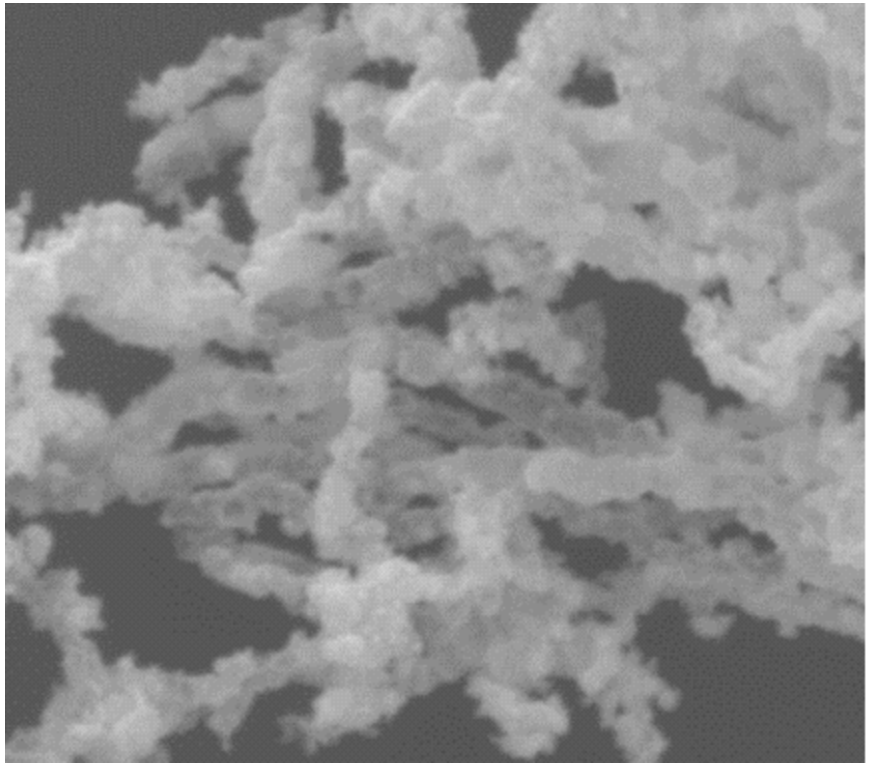


Approach

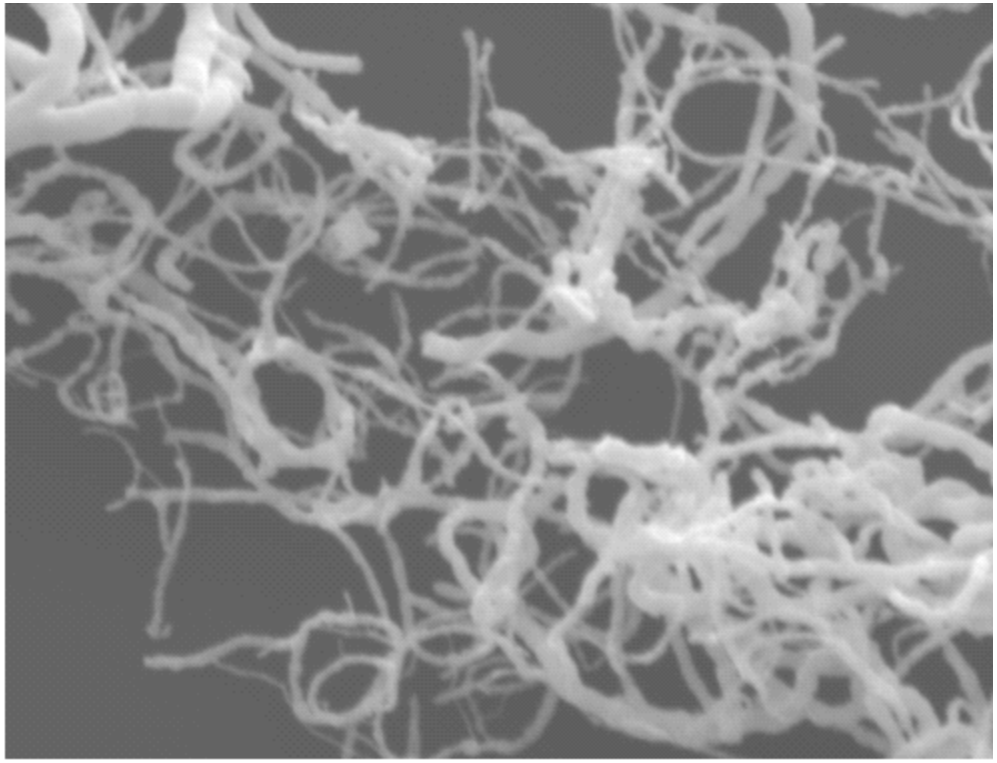
2012 Milestones

- **Fabricate 2 different Pt alloy ETFECS that demonstrate 2X specific activity relative to pure Pt ETFECs**
  - Both milestones were completed: PtNi nanowires and PtCo nanowires

PtNi nanowires



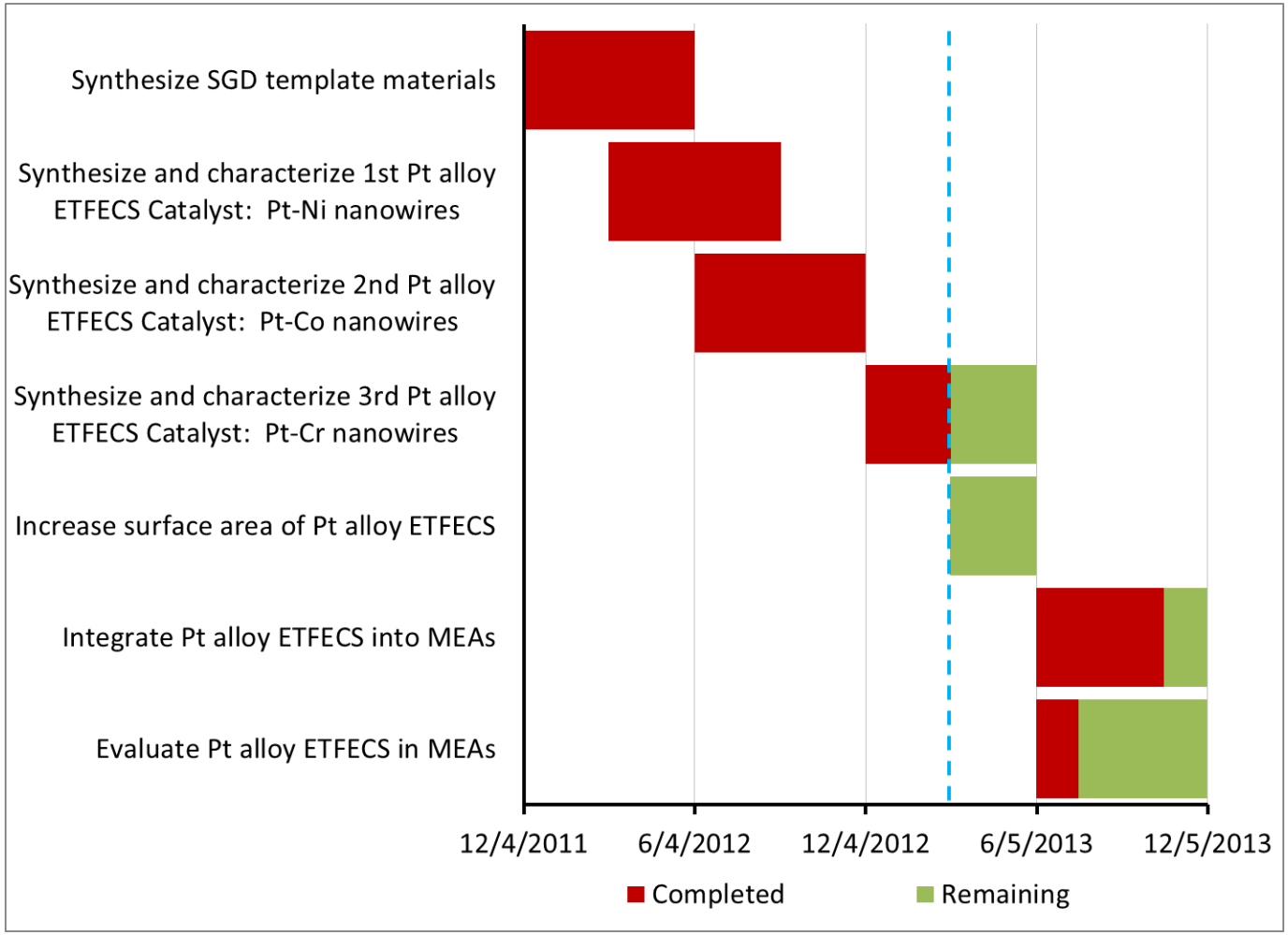
PtCo nanowires



Approach

Progress & Milestones

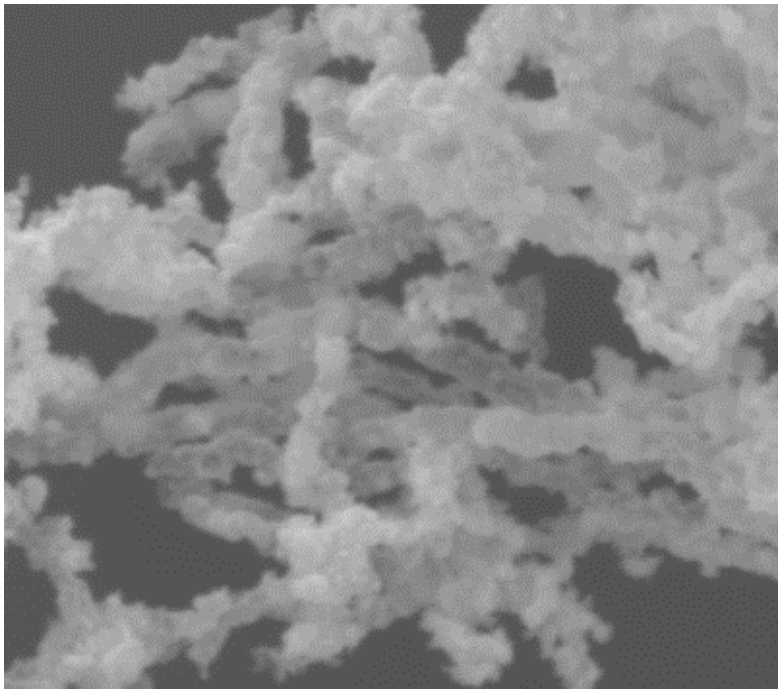
- All past project milestones have been completed on schedule and future milestones are on schedule or ahead of schedule

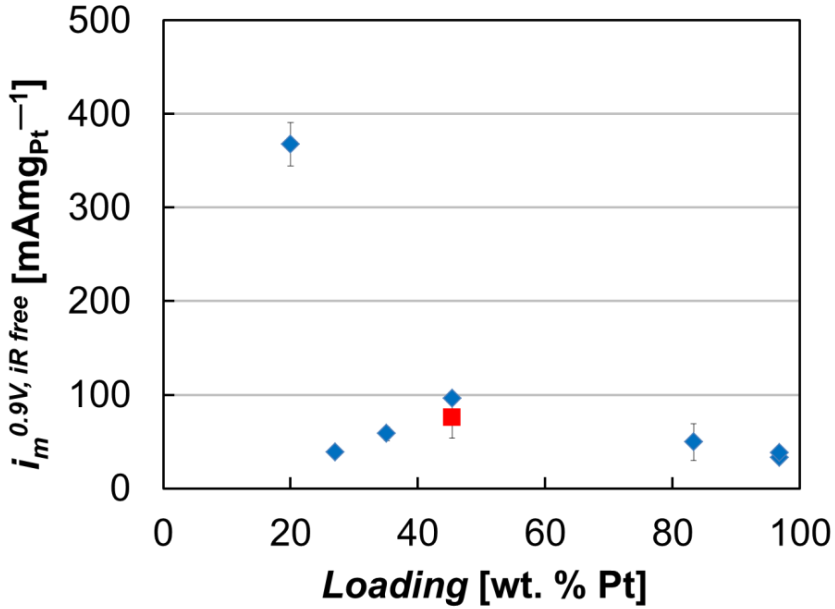


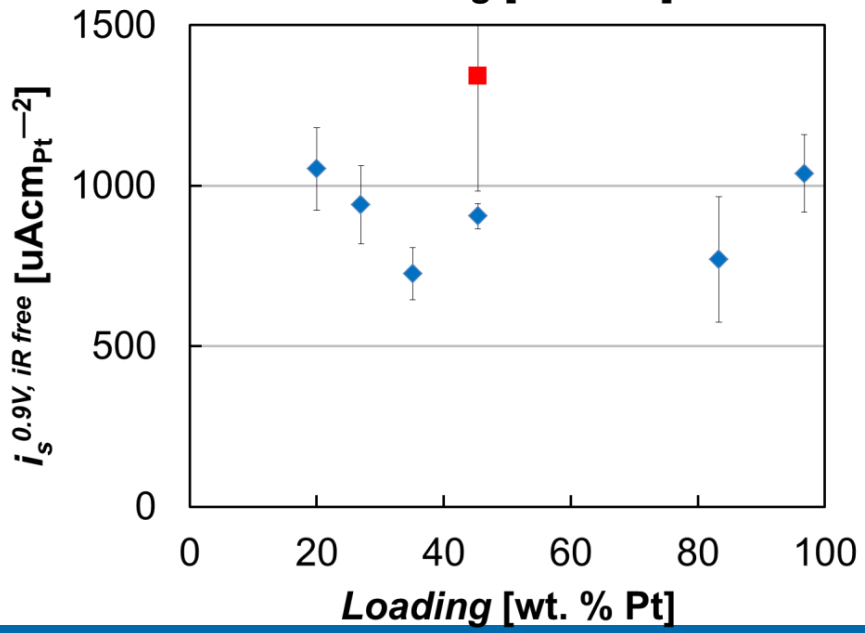
Accomplishments

PtNi nanowires with mass activity of 380 mA/mg_{Pt}

- **Synthesized by galvanic displacement of commercially available Ni nanowires**
- **Highest mass activity at low Pt loading**
- **Specific activity increased as high as 1400 $\mu A/cm^2$ after thermal annealing, but greatly decreased surface area**



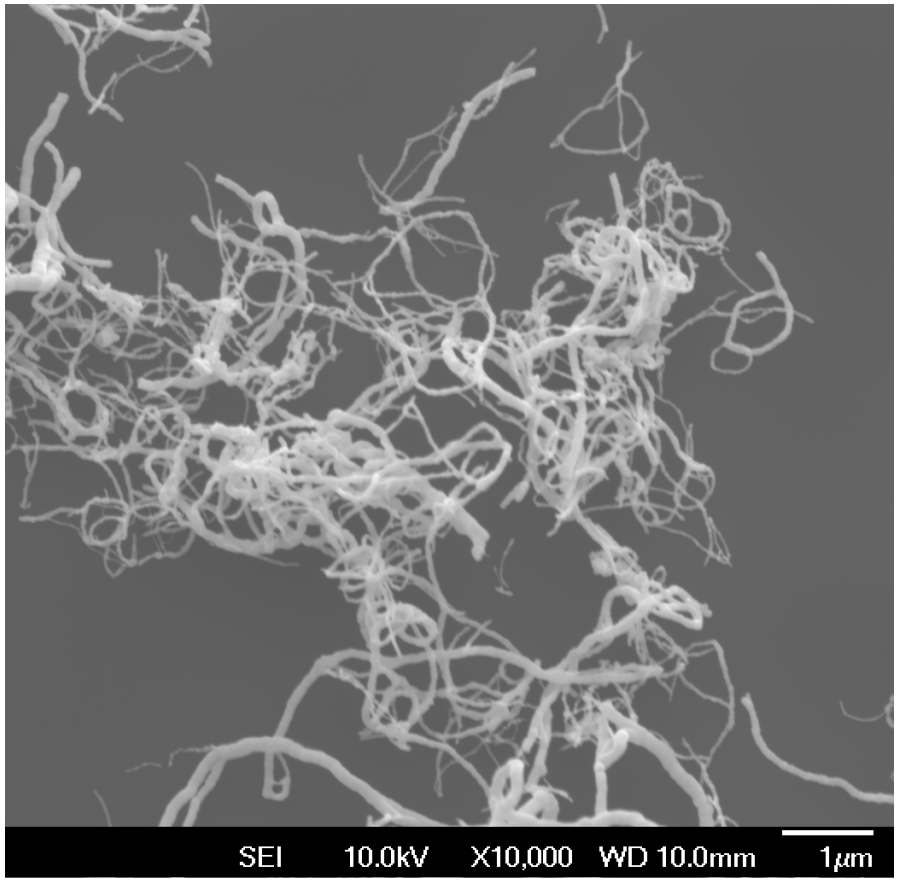


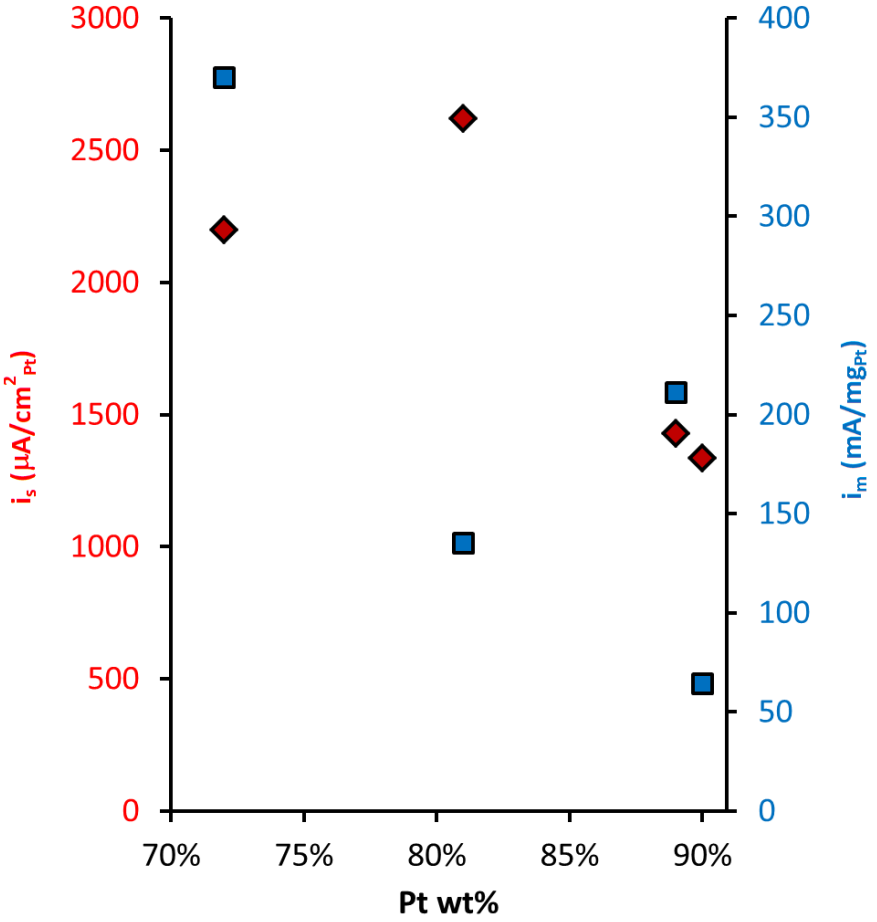


Accomplishments

PtCo nanowires with mass activity of 370 mA/mg_{Pt}

- Synthesized by solvothermal reduction of $Pt(AcAc)_2$ and decomposition of $Co_2(CO)_8$
- Highest mass activity at low Pt loading
- Very high specific activity: 2600 µA/cm^2



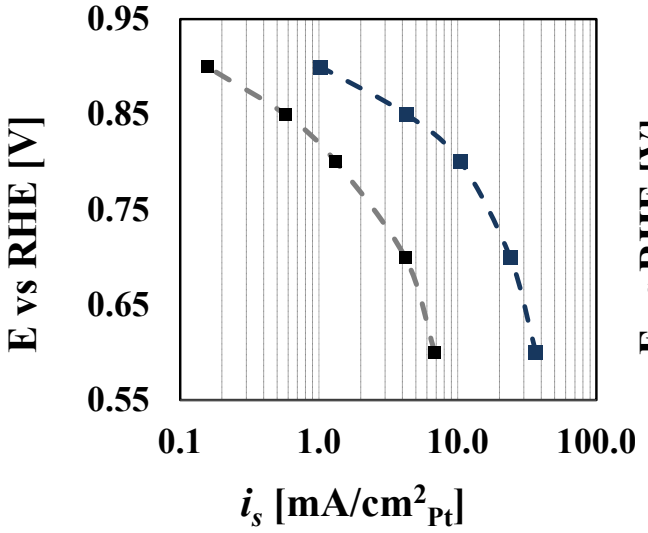


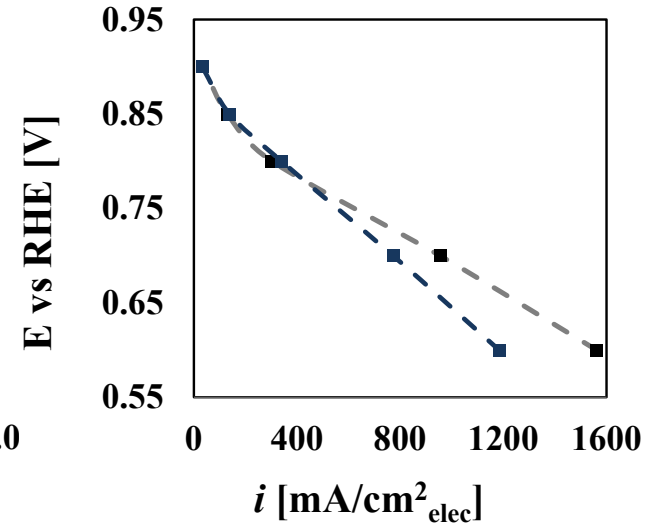
Accomplishments

Integration of PtCo nanowires in MEAs

- **Best ETFECS MEA performance to date**
  - Greatly improved results relative to Pt ETFECS in MEAs
  - Favorable performance relative to 50 wt% Pt/HSC baseline

	50 wt% Pt/HSC baseline			50 wt% PtCo ETFECS		
	ECA m^2_{Pt}/g_{Pt}	i_s corr uA/cm^2_{Pt}	i_m corr mA/mg_{Pt}	ECA m^2_{Pt}/g_{Pt}	i_s corr uA/cm^2_{Pt}	i_m corr mA/mg_{Pt}
RDE	100	275	275	17	2200	370
MEA	82	160	130	14	1050	150





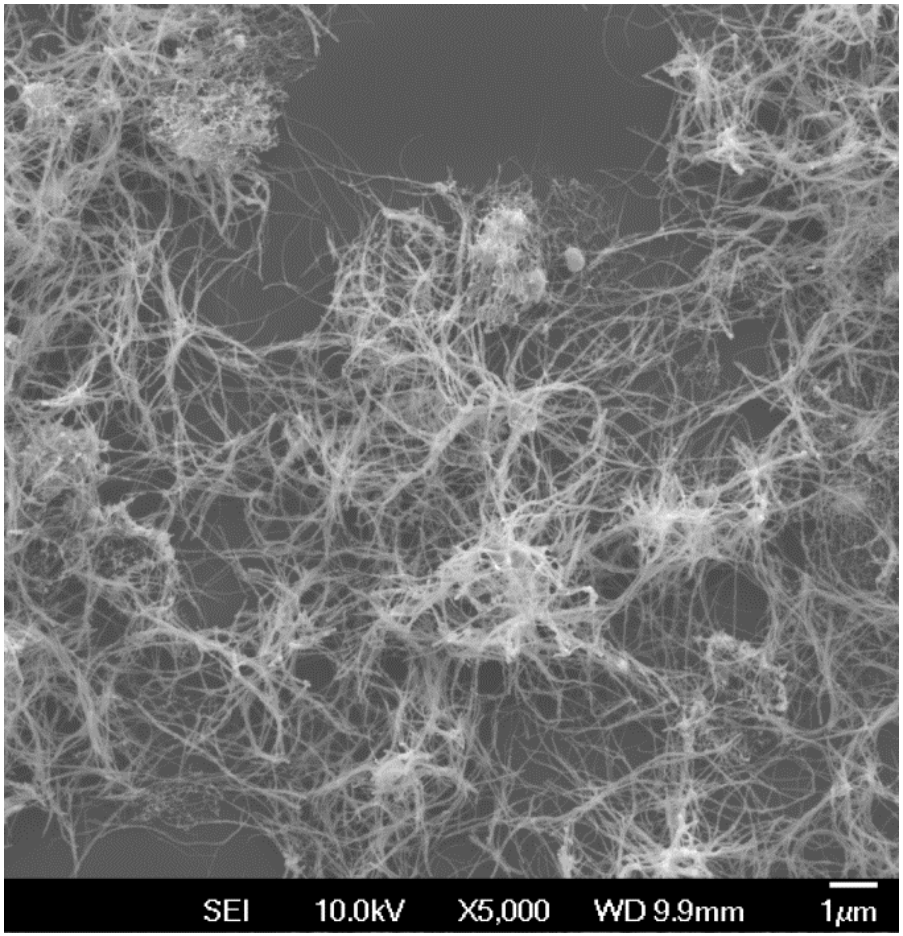
Testing Conditions:

5cm²-single serpentine flow field
80°C 100% RH
H_2/O_2 150/300 sccm
150 kPa (~100 kPa H_2/O_2)
N212 Membrane

15 min per point –Anodic Sweep
JM-GDE (Anode)/SGL25BC Cathode
0.28 mg_{Pt}/cm^2_{elec} –Pt/HSC
0.22 mg_{Pt}/cm^2_{elec} –PtCo w/GCNF2

Recommended Future Work

- **Synthesis and characterization of PtCr nanowires**
  - Have already synthesized PtCr materials
  - RDE testing is on-going



Recommended Future work

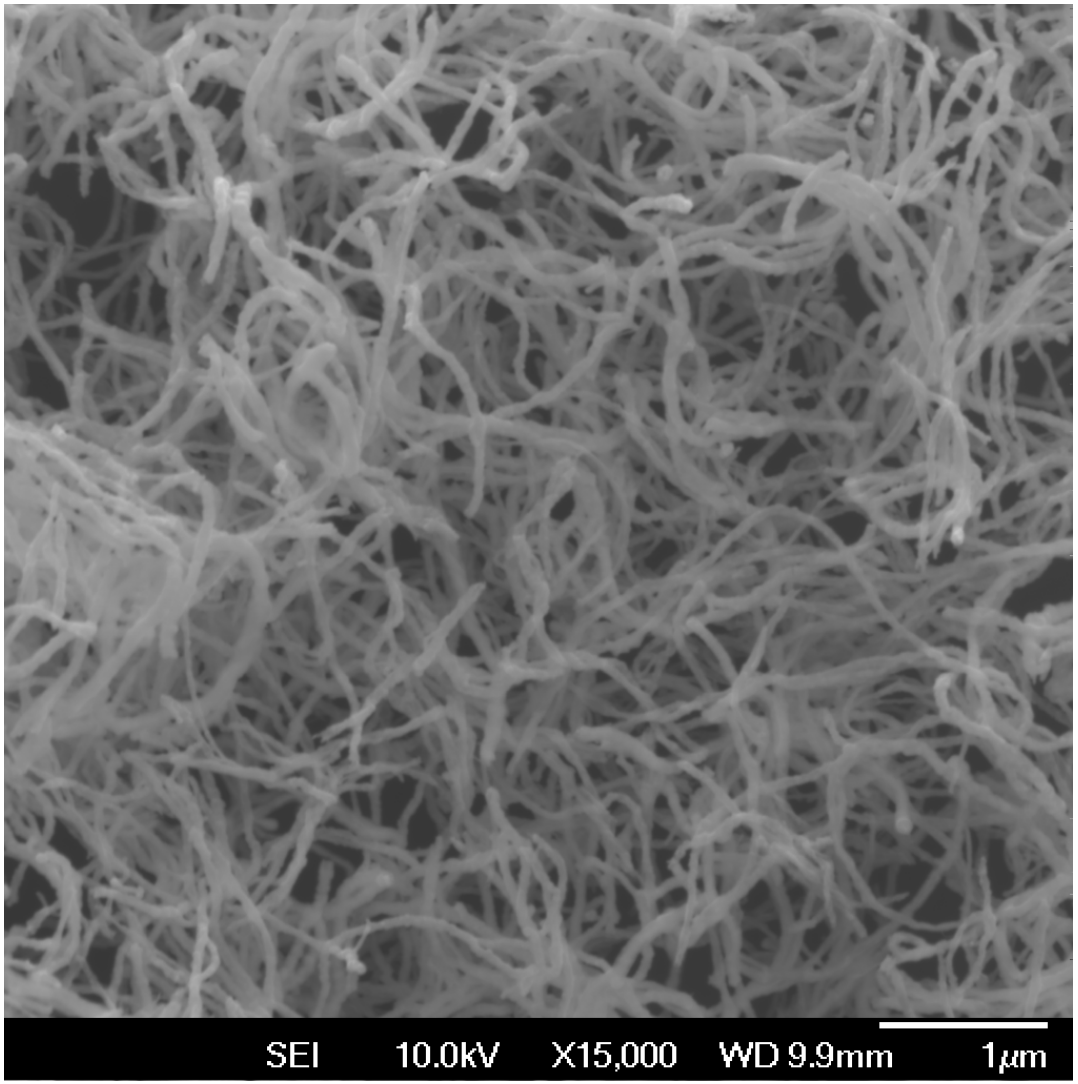
Increase surface area of ETFECS materials

- Synthesize ternary Pt-alloy ETFECS with sacrificial “leachable” metal (e.g. Fe, Mn)

Improve MEA integration of Pt-alloy ETFECS

- Increase performance at high current densities

Ternary Pt-alloy ETFECS: $Pt_{22}Co_{75}Cr_3$



Summary Slide

- **Relevance**
  - Produce novel high aspect ratio nano-structured Pt-based catalyst materials with increased activity and increased Pt utilization, moving towards meeting all 2017 DOE catalyst targets
- **Approach**
  - Synthesize Pt-alloy ETFECS materials with improved activity relative to pure Pt ETFECS
- **Accomplishments**
  - Synthesized PtNi and PtCo nanowire ETFECS with high mass activities (380 and 370 mA/mg_{Pt})
  - Integrated PtCo in MEAs and outperformed Pt/HSC
- **Recommended Future work**
  - Synthesize PtCr nanowire ETFECS
  - Synthesize Pt ternary nanowire ETFECS to improve surface area
  - Continue Pt alloy ETFECS integration in MEAs