

High Performance and Durable Low PGM Cathode Catalysts

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FC120

This presentation does not contain any
proprietary or confidential information

Project Overview

Timeline

- **Project Start Date**
September 2014
- **Project Duration**
1 year
- **Project End Date**
September 2015

Budget

- **Total project funding**
\$300K for FY2015
 - PNNL: \$180k
 - LANL: \$120k

Barriers

- **Durability (cathode)**
- **Cost (catalyst)**
- **Performances (loss and activity)**

Partners

- **2 National Laboratories**
 - PNNL (lead)
 - LANL

Relevance and Objectives

Relevance:

2020 DOE Targets for Electrocatalysts

- Platinum group metal total content: 0.125 mg PGM/cm²
- Mass Activity (A/mg Pt@ 900 mV (IR free)): 0.44
- Loss in initial activity (mass activity loss): < 40%
- Electro catalyst support stability (mass activity loss): <10%

Objective:

Improve stability of catalysts by enhancing metal/support interactions and improved carbon support durability.

Approaches

- “2-D to 3-D” engineering of graphene to enhance the diffusion properties
- ITO coating to improve the durability
- Pt loading using chemical reduction method developed at PNNL and vapor deposition method developed at LANL
- Electrochemical evaluation using an RDE test station to demonstrate both the ORR activity and stability using the standard DOE protocol.
- MEA Fuel cell testing at LANL (1.2V/400h hold, measuring ORR every 24h) will be used to demonstrate the durability of Pt-ITO-3D graphene catalyst. CO₂ generation rates will be determined to measure carbon support loss.
- Build off of our strong base in fundamental catalysis science:
 - Institute for Integrated Catalysis (IIC),
 - Environmental Molecular Sciences Laboratory (EMSL)

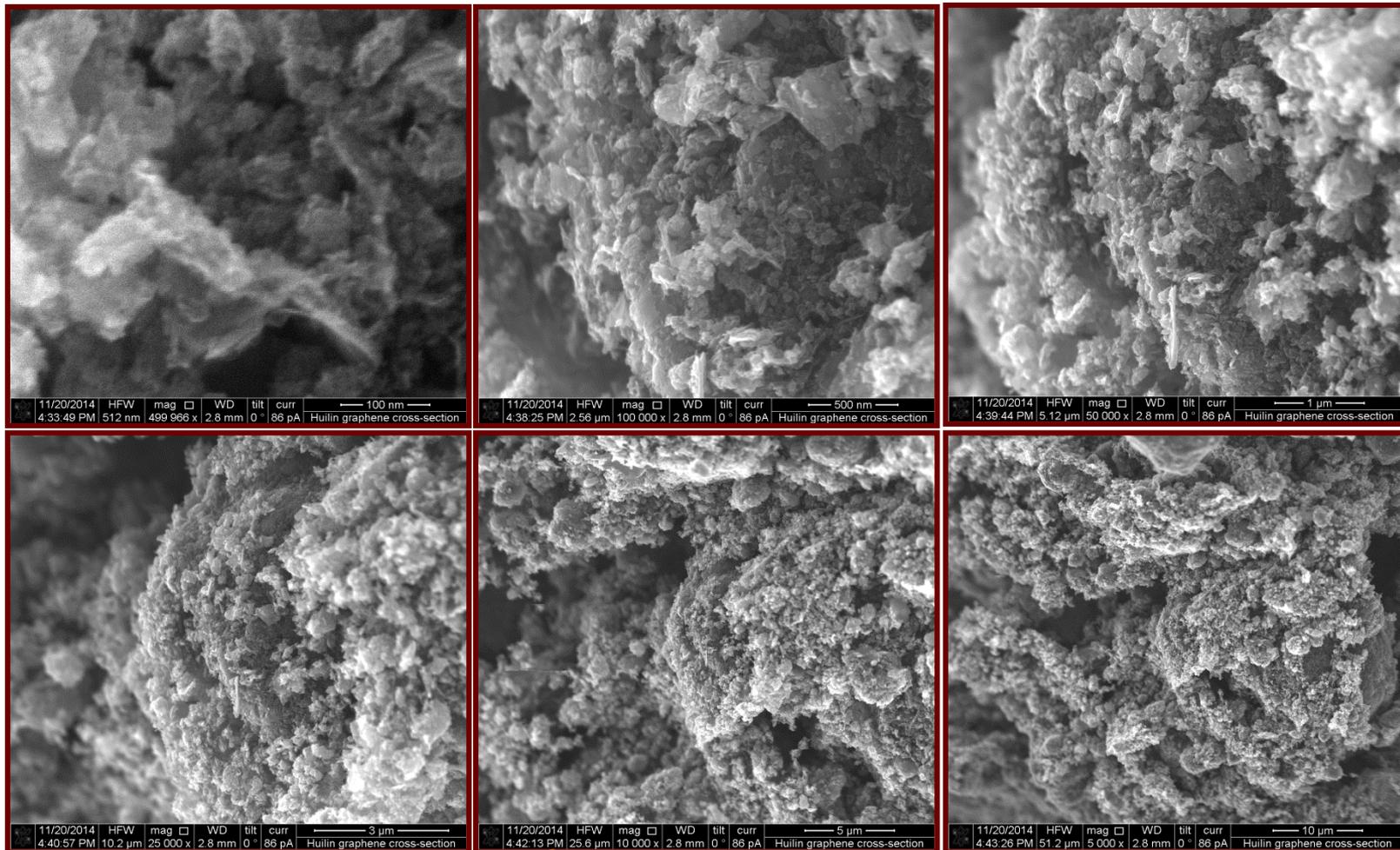


Milestones

Status	Due Date	Type	Milestones, Deliverables, or Go/No-Go Decision	Decision Criteria
Met	11/13/2014	Regular	2-D to 3-D engineering of graphene support	Successfully fabricate a 3-D porous structure. Target is to produce 10grams
Met	12/31/2014	Regular	Pt deposition on ITO-modified 3-D support	Deposit PT achieving a <4 nm Pt particle size
Met	3/31/2015	Stretch	RDE test of 3-D porous electrocatalysts	Report on the ability to achieve an ORR 80 mA/mg with 20% higher durability than baseline.
Progress	6/30/2015	Stretch	<p>MEA test of optimized catalysts</p> <p><u>Deliverable:</u> provide pathway to</p> <ul style="list-style-type: none"> •reduce Pt loading by factor of 3 to achieve 240 mA/mg Pt •Mass activity loss <10% 	Report on the ability to achieve an ORR 80 mA/mg, 2X reduction in carbon corrosion over baseline and < 20% loss in activity after 1.2V hold test.

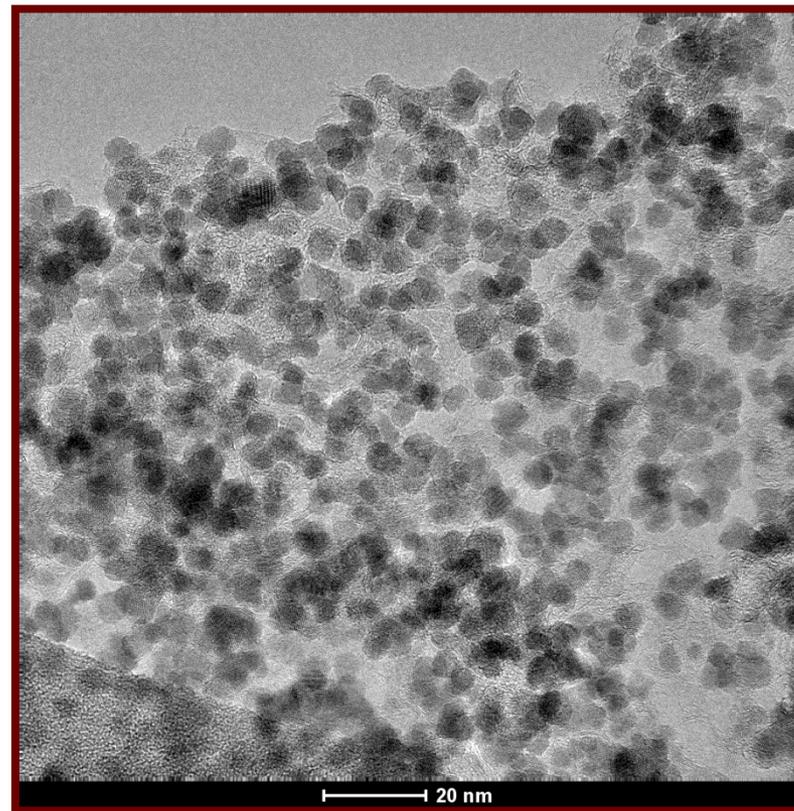
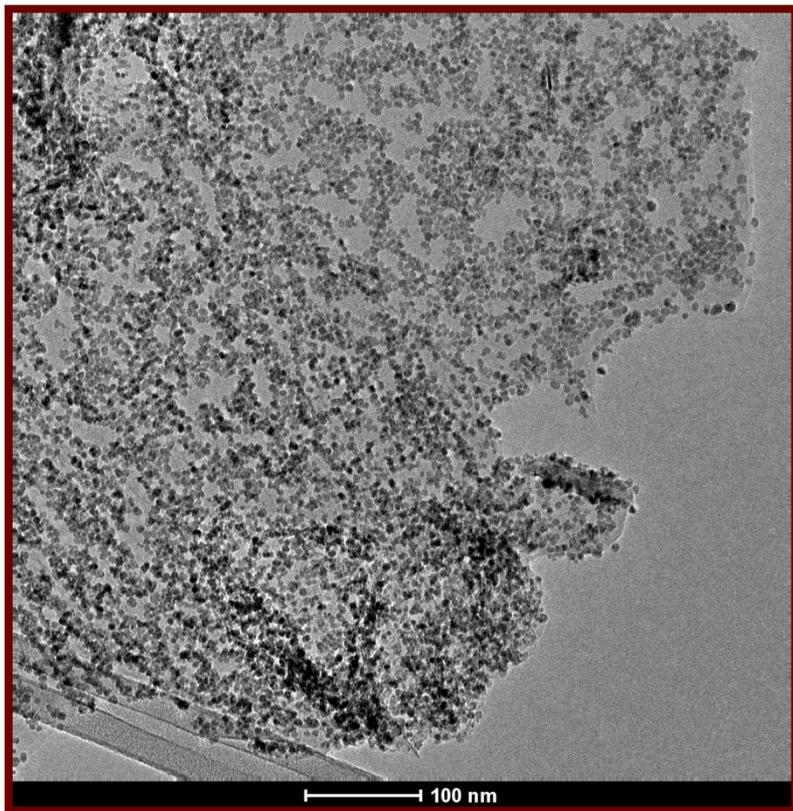
Technical Accomplishments

Success in Synthesizing 3D Graphene



Technical Accomplishments

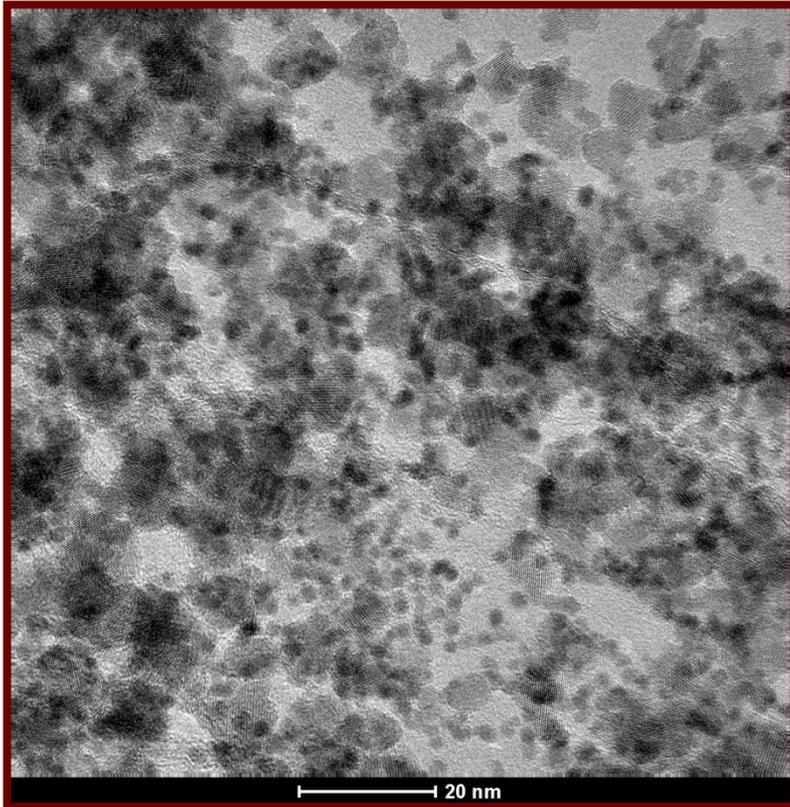
Highly Dispersed ITO on 3D Graphene



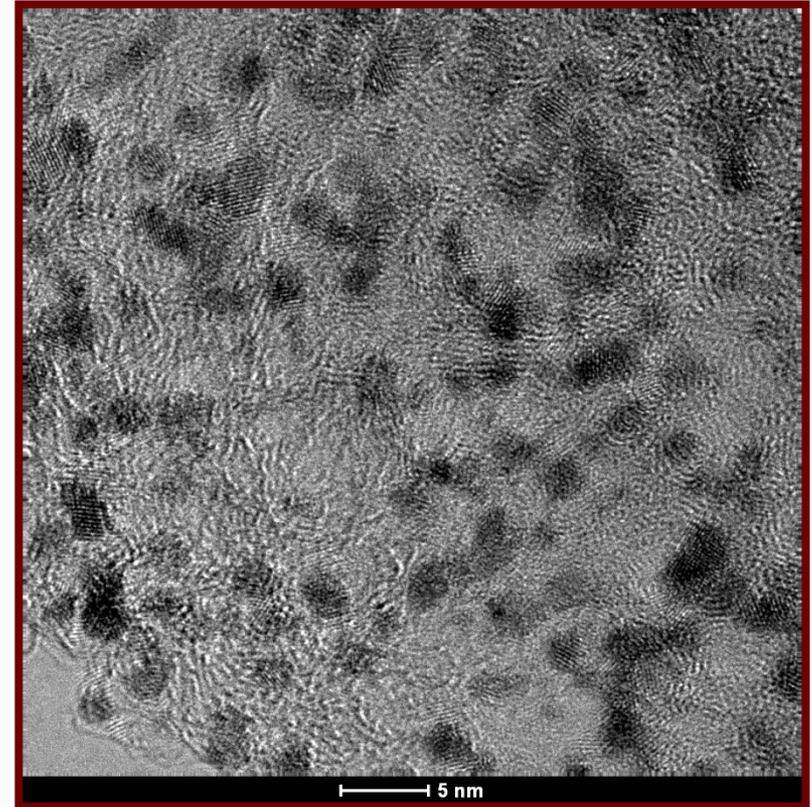
Technical Accomplishments

Pt loaded onto 3D Graphene Using Solution Chemistry Method

With ITO

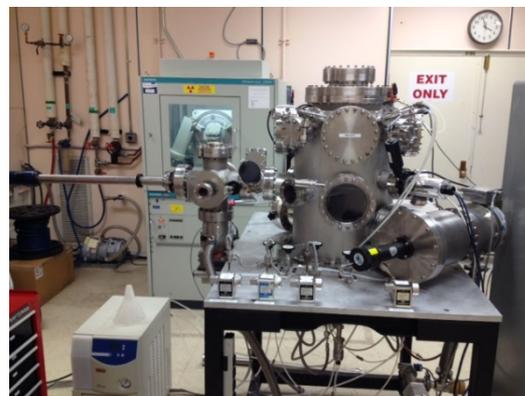


Without ITO



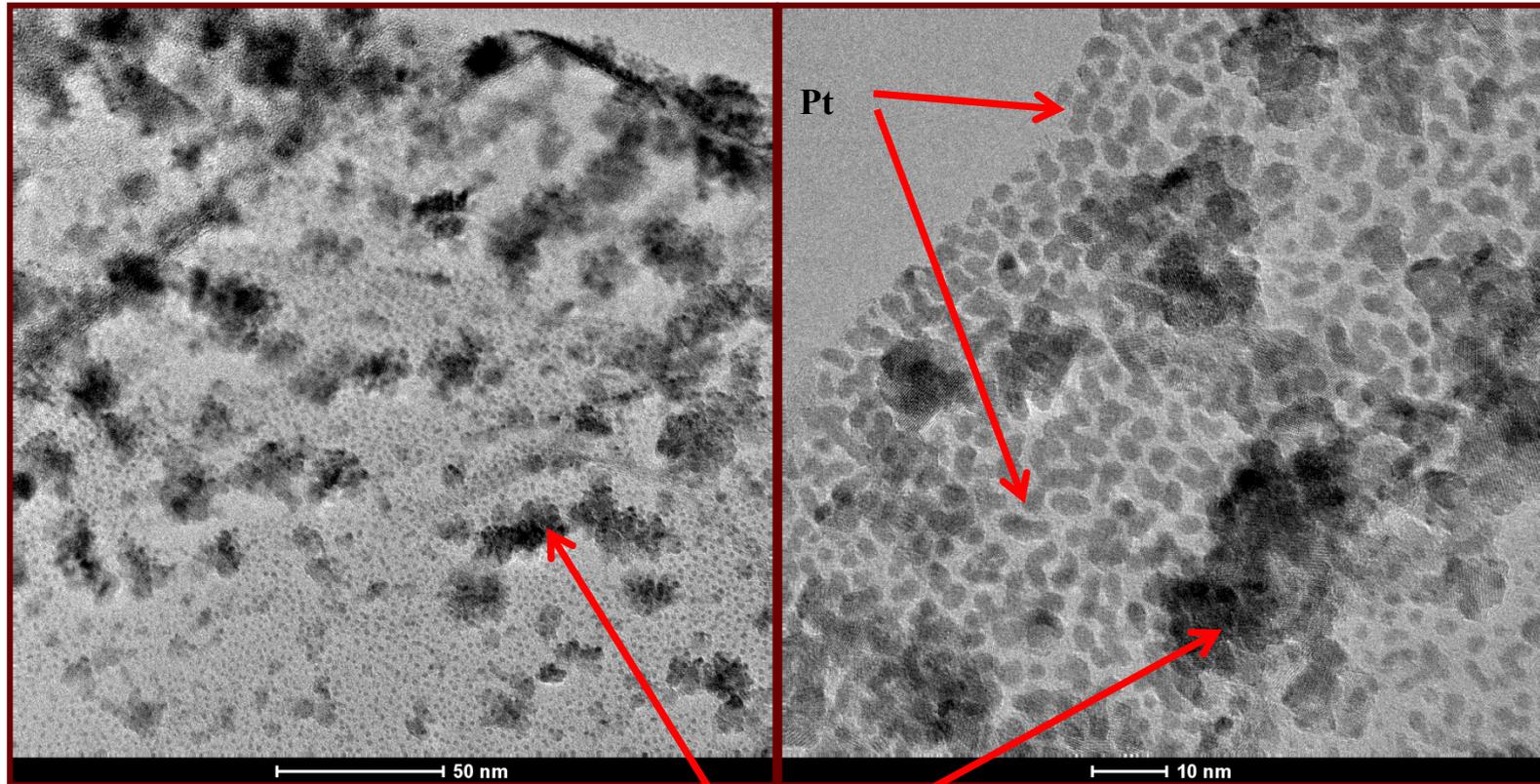
Pt Coating Using PVD at LANL

- Dedicated sputter deposition system.
 - 4 sputter guns (1 DC, 3 RF), Load lock chamber and two turbo pumps came with system
 - Inficon QCM rate monitor for programmed depositions
 - 4 controlled-leak valves for reactive sputtering
- Large chamber / interior volume to accommodate experiment and project growth
- Special BN vacuum built to accommodate acoustic motor and post affixing Chladni plate designed for the project



Technical Accomplishments

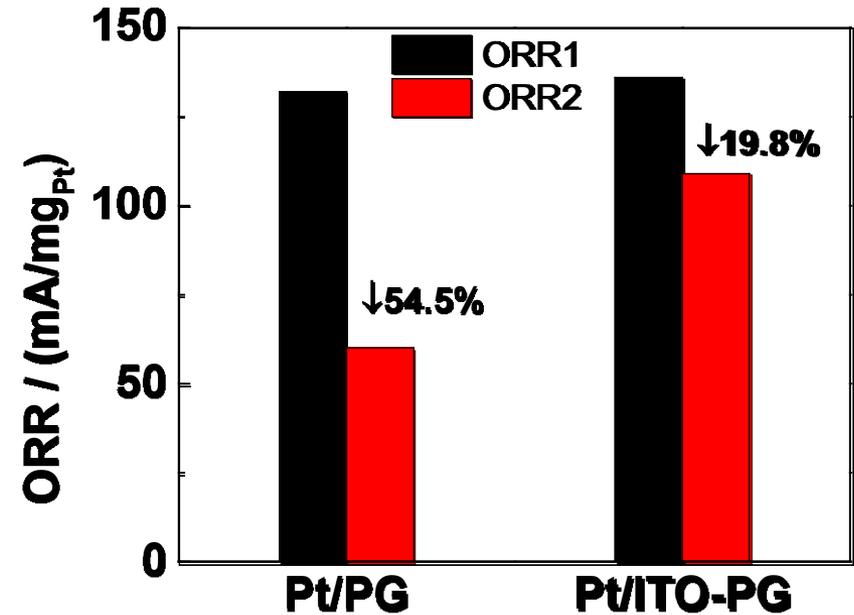
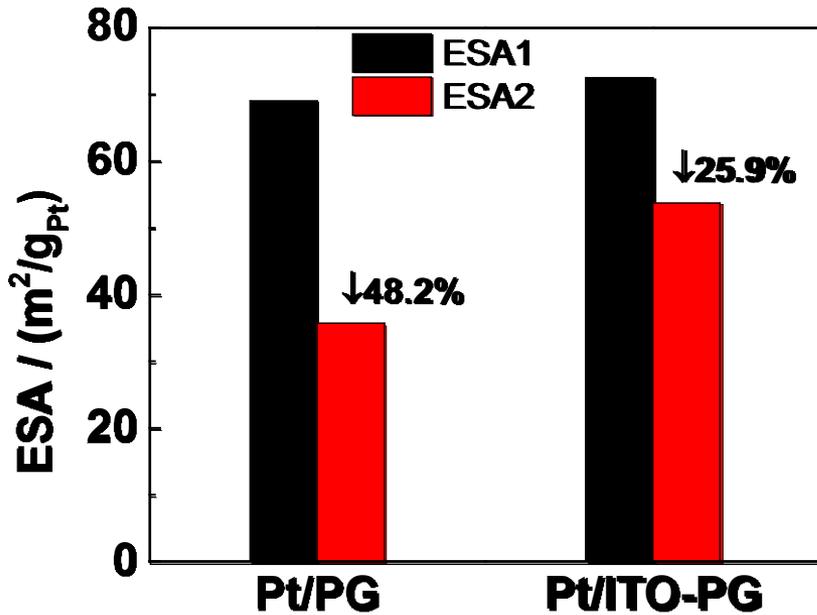
Pt deposition by PVD method



ITO

Technical Accomplishments

Improved Electrochemical Activity/Durability



Performances exceeds the targets:

- ORR: $135\text{mA}/\text{mg}_{\text{Pt}}$ vs $80\text{mA}/\text{mg}_{\text{Pt}}$
- Durability: 1.86X (ESA), 2.75X (ORR) vs. 1.2X

Technical Conclusions/Summary

- **Successfully synthesized 3D structured graphene**
- **Highly dispersed ITO on 3D structured graphene can be synthesized using solution chemistry method**
- **Both solution chemistry method and PVD are able to highly disperse Pt nanoparticles on ITO coated 3D graphene**
- **Activity and durability exceed proposed targets.**

Future Work

- **Demonstrate MEA activity/durability using Pt/ITO-3D graphene**
- **Optimize electrocatalyst through post-treatment.**
- **Optimizing PVD system for Pt deposition**

Collaborations

PNNL

- **Synthesis of support materials**
- **Deposition of Pt by solution chemistry**

LANL

- **Deposition of Pt by acoustic agitated PVD**
- **MEA fabrication**
- **MEA Testing**

Publications/Presentations

- Y Shao, Y Cheng, R Kou, Y Wang, J Liu. “Durable Nanostructured Electrocatalysts for Oxygen Reduction Reaction: Materials Design and Testing Protocol.” 2015 MRS Spring Meeting & Exhibit April 6-10, 2015, San Francisco, California
- Y Shao, Y Wang, J Liu. “Porous nanocomposite from scalable synthesis for electrocatalytic applications”. Invention Report filed on Dec. 9/2014.
- R Borup, E Brosha, J Liu, Y Shao, Y Wang, T Rockward, Fuel Cell Tech Team Review, Detroit, May 13 2015.

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