Non-Precious Metal Bi-Functional Catalysts

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pH Matter, LLC

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Project ID: FC134

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Company Background

- Small Business, founded in 2010, located in Columbus, OH
- Equipment for catalyst and fuel cell development
- Nearby Ohio State University characterization facilities
- Mission: to develop and commercialize catalyst-based products for alternative energy applications.
- Expertise in:
  - Catalyst synthesis, development, and scale-up
  - Fuel Cell and electrochemical device development
  - Commercialization of catalysts, advanced materials, and electrochemical devices

Project Background

- Fuel cells are of interest for energy storage applications, such as grid load leveling.
- The fuel cells could potentially be operated in a reversible manner, allowing renewable energy to be stored in the form of hydrogen.
- When operating in regeneration mode, cathode degradation is even more pronounced for conventional metal catalysts because of the high voltages required for OER.
- In existing reversible systems, a separate electrode is typically used for oxygen evolution, adding to the already high system cost.
- If a low-cost bi-functional cathode could be developed for reversible fuel cells, it would be a key breakthrough in the commercial viability of fuel cell systems for grid energy storage.

Overview

Timeline and Budget

- Phase I SBIR Project
- Project Start Date: 02/17/2015
- Project End Date: 11/16/2015
- Total FY15 Project Budget: $150,000

Barriers

- Barriers addressed:
  - Develop non-PGM catalysts for reversible anion-exchange membrane fuel cells (oxygen reduction and oxygen evolution)
  - Increase the durability/stability of catalysts with potential cycling
  - Integrate catalysts with membranes and GDLs into MEA
- Targets:
  - Hundreds of cycles with less than 10% voltage loss
  - Power density competitive with PGM catalysts (>350 mW/cm^2 at 0.8 V vs. RHE)

Relevance

The DOE has a mission to develop lower cost and better performing fuel cell technologies, and develop technologies for grid load leveling. This project applies to both.

Project Objectives

- Prepare and characterize a matrix of catalysts and MEAs for use in reversible AEMFC systems.
- Demonstrate a bi-functional GDE that is consistent with DOE AEMFC performance targets (350 mW/cm^2, <10% degradation over hundreds of cycles).
- Perform economic analysis on reversible AEMFC system following established DOE guidelines for candidate grid load leveling technologies (see Steward et al., NREL/TP-560-46719, 2009).

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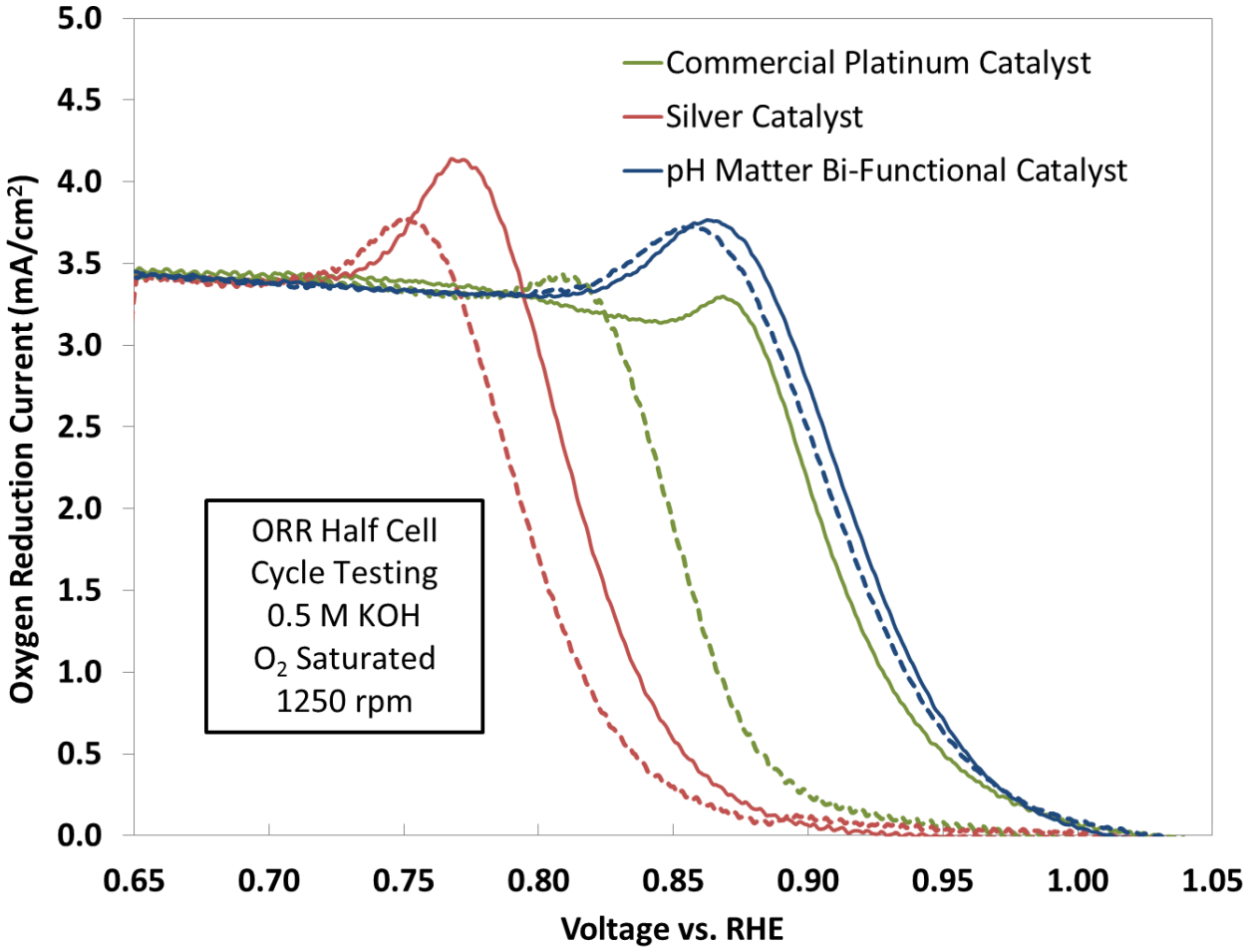
Approach

Task / Milestone	Month after Project Initiation								
	1	2	3	4	5	6	7	8	9
Task 1. Material Synthesis and Characterization	——	——							
Initial sample matrix complete	●								
Characterization reported		●							
Task 2. MEA Fabrication and Characterization		——	——	——	——	——	——		
MEAs available for testing			●						
Optimized MEAs prepared							●		
Task 3. MEA Testing				——	——	——	——	——	——
Initial MEA testing reported					●				
>100 cycles at 350 mA/cm^2 with <10% degradation									●

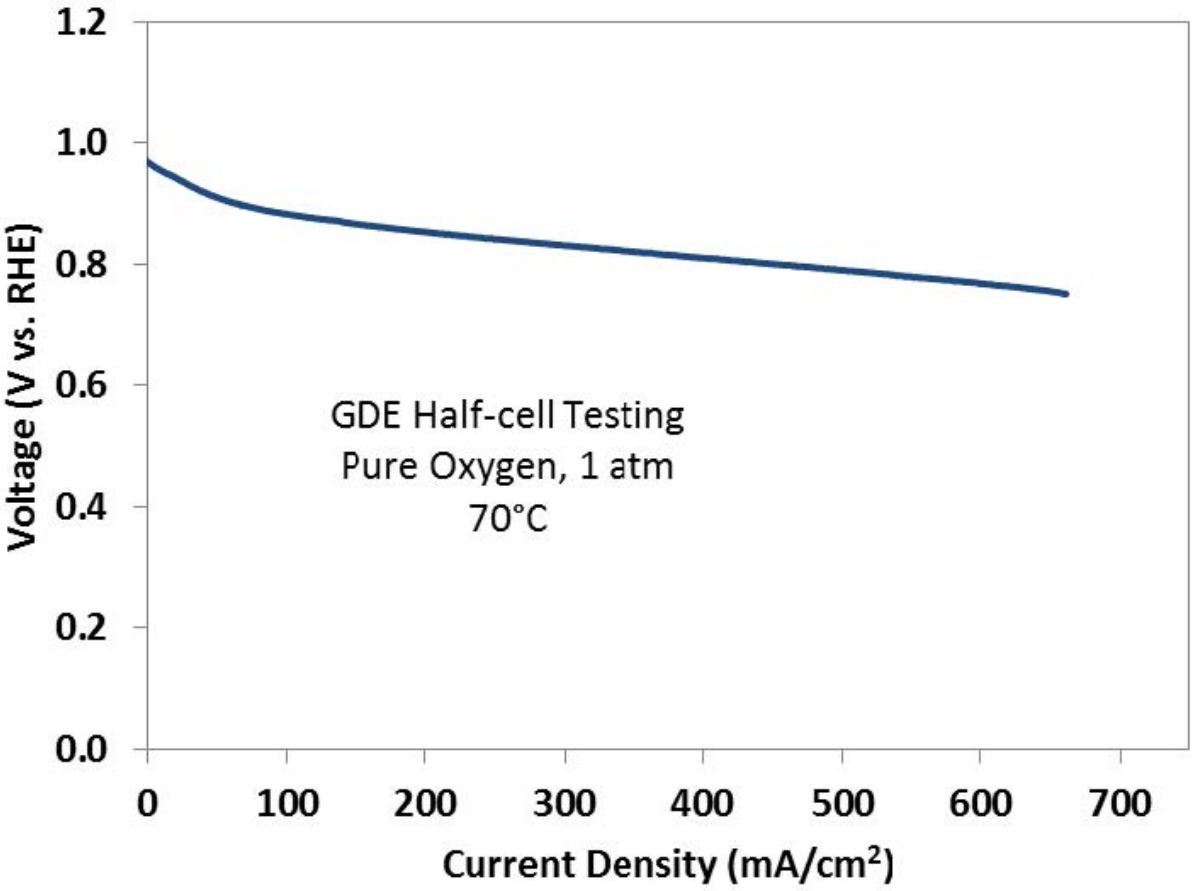
Accomplishments

- Identified a series of catalysts with excellent performance and cycling durability in RDE testing:



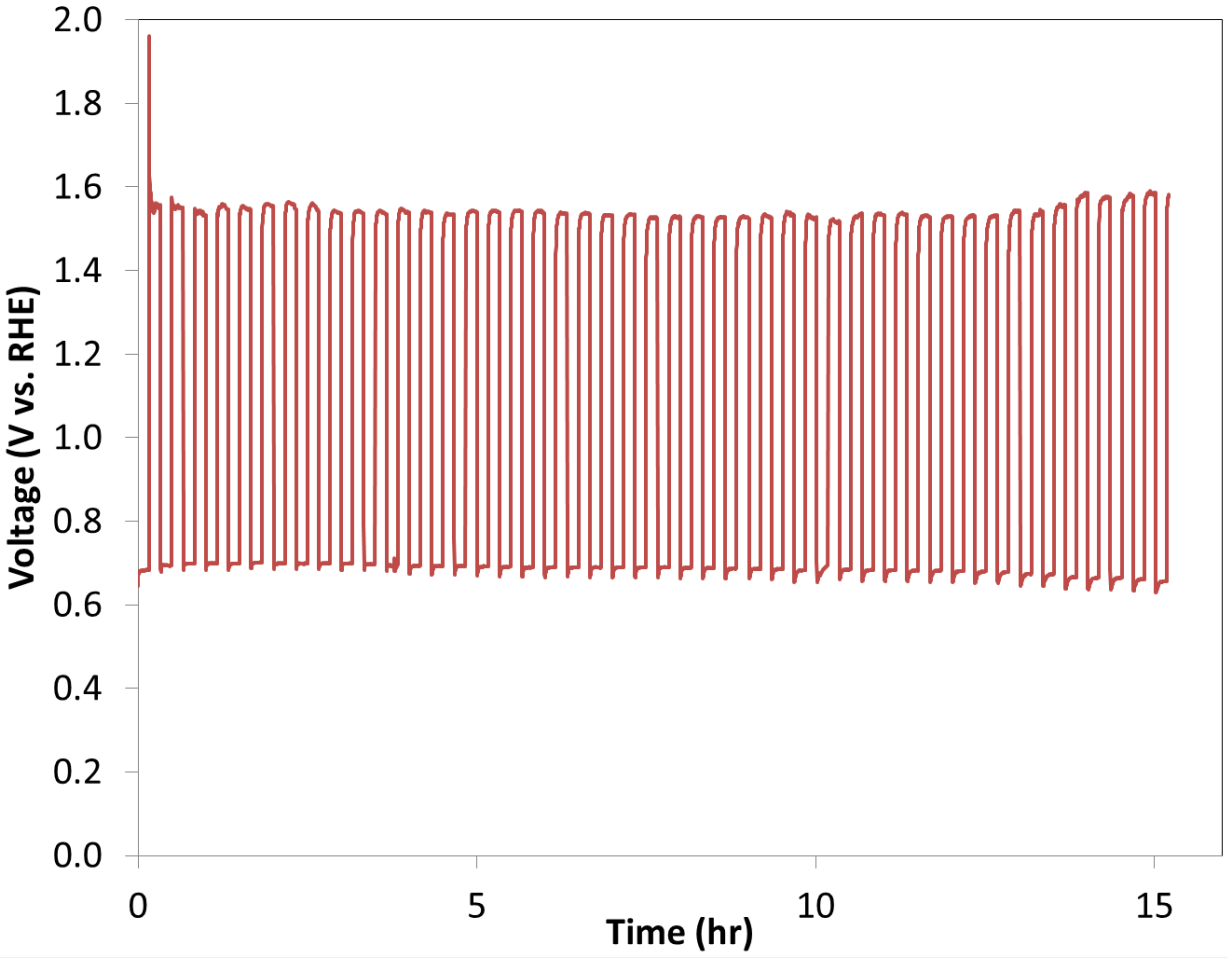
Accomplishments

- Demonstrated that high ORR performance is achievable in GDE testing with bi-functional catalyst:



Accomplishments

- Demonstrated that stability in RDE testing can be replicated in GDE ORR/OER cycle testing:



Proposed Future Work

- Optimize the GDEs and AEM interface.
- Demonstrate high power for ORR in conjunction with cycling durability (ORR/OER).
- Demonstrate durability over hundreds of cycles.
- Demonstrate the bi-functional GDE in full cells.
- Characterize the electrodes before and after cycling to better understand any degradation mechanisms.
- Perform economic analysis for a reversible AEMFC to better understand requirements for grid load leveling applications.

Summary

- Reversible fuel cells are an interesting energy storage technology for a number of applications, including grid load-leveling.
- pH Matter, LLC is developing non-PGM bi-functional GDEs for AEMFCs; the technology could be a breakthrough for reversible fuel cells.
- The GDE technology is also applicable to AEMFC targets for performance and durability.
- Future work aims to achieve performance and durability that projects to economic feasibility for the technology.

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