pH¹ Matter LLC

Regenerative Fuel Cell System (SBIR Phase II)

Paul Matter, PhD

June 8, 2016

Project ID: **FC154**

pH1 Matter LLC

Company Background

- Small Business, founded in 2010, located in Columbus, OH
- Mission: to develop and commercialize material-based products for alternative energy applications.
- Primary focus on catalyst and electrode materials
- Expertise in:
  - Catalyst synthesis, development, and scale-up
  - Fuel Cell and electrochemical device development
  - Commercialization of catalysts, advanced materials, and electrochemical devices

pH1 Matter LLC

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, degradation is even more pronounced for conventional metal catalysts because of the high voltages required.
- In existing reversible systems, a separate electrode is typically used for oxygen evolution, adding to the already high system cost.
- If a low-cost reversible fuel cell could be developed, it would be a key breakthrough for grid energy storage.

pH1 Matter LLC

Overview

Timeline and Budget

- Phase II SBIR Project
- Project Start Date: 04/11/2016
- Project End Date: 04/10/2018
- Total Project Budget: $1M

Collaborators

- Giner
- NREL

Barriers

- Barriers addressed:
  - Develop catalysts for the oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) for reversible anion-exchange membrane fuel cells (AEMFC) .
  - Increase the durability/stability of catalysts with cycling
  - Integrate catalysts with membranes and gas diffusion layers (GDLs) into membrane electrode assemblies (MEAs) and stacks
- Targets:
  - 1,000 cycles above target operating efficiency and current density
  - 42% efficiency; >250 mA/cm^2 power generation; >50 mA/cm^2 energy storage

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

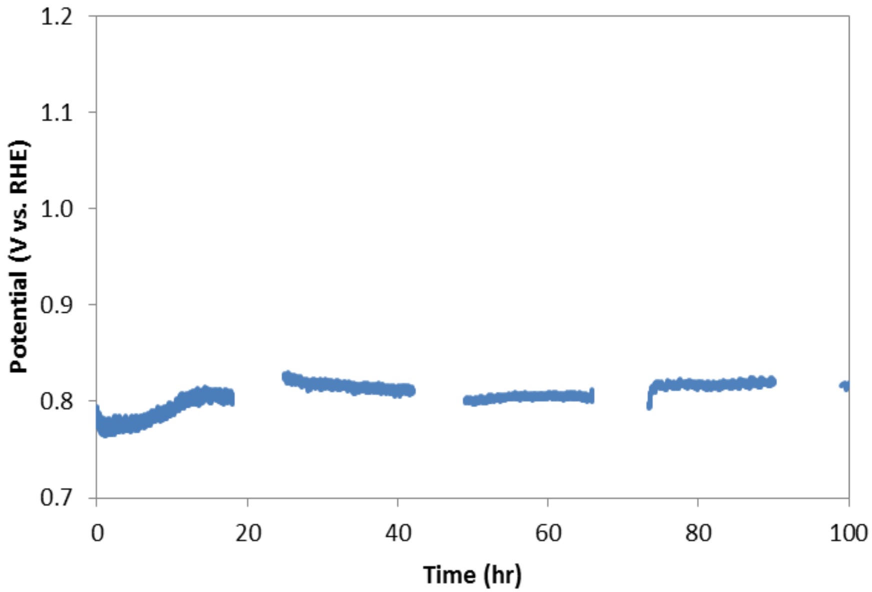
- Demonstrate a reversible 25-cm^2 AEMFC for 1,000 cycles (42% round-trip efficiency; >250 mA/cm^2 power generation; >50 mA/cm^2 energy storage).
- Incorporate MEAs into regenerative stack.
- Perform economic analysis on reversible AEMFC system following established DOE guidelines for candidate grid load leveling technologies.

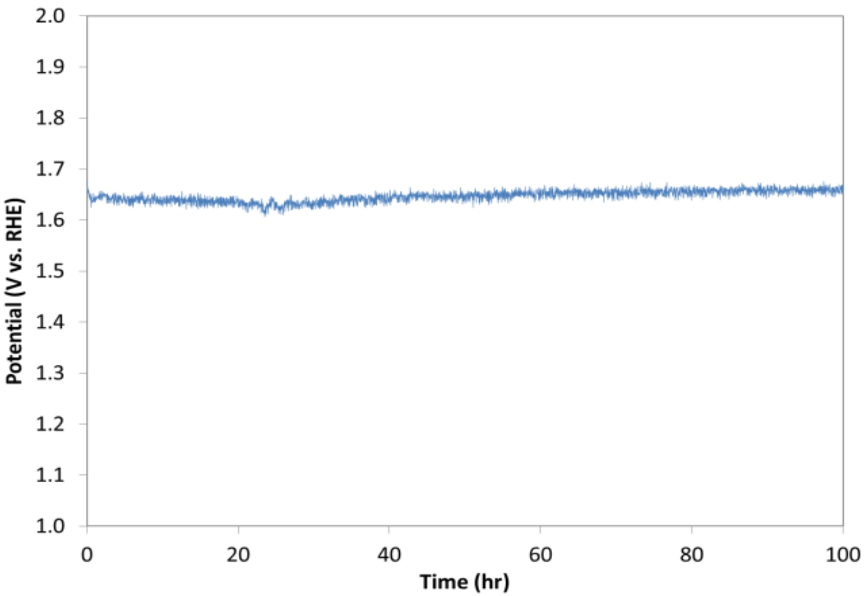
Approach

Tasks / Key Milestone	Quarter							
	1	2	3	4	5	6	7	8
Task 1. Hydrogen Electrode Development	■ ■	■ ■	■ ■	■				
Task 2. MEA Development								
Task 2.1 MEA Synthesis	■ ■	■ ■	■ ■	■ ■				
Task 3. Fuel Cell Testing								
Task 3.1 Performance Testing		■ ■	■ ■	■ ■				
> 250 mA/cm^2, >42% efficiency at 25-cm^2				●				
Task 3.2 Load Cycle Testing				■ ■	■ ■	■ ■		
1,000 cycles demonstrated						●		
Task 3.3 Post-test Characterization					■ ■	■ ■	■ ■	
Task 4. 5-cell Stack Testing								
Task 4.1 Fabrication					■ ■	■ ■	■ ■	
Task 4.2 Stack Testing						■ ■	■ ■	■ ■
stack demonstrated								●
Task 5. Economic Modeling								
Task 5.1 Material Scale-up Projections	■ ■	■ ■	■ ■	■ ■				
Task 5.2 Delivered Electricity Projections				■ ■	■ ■	■ ■	■ ■	■ ■

Accomplishments

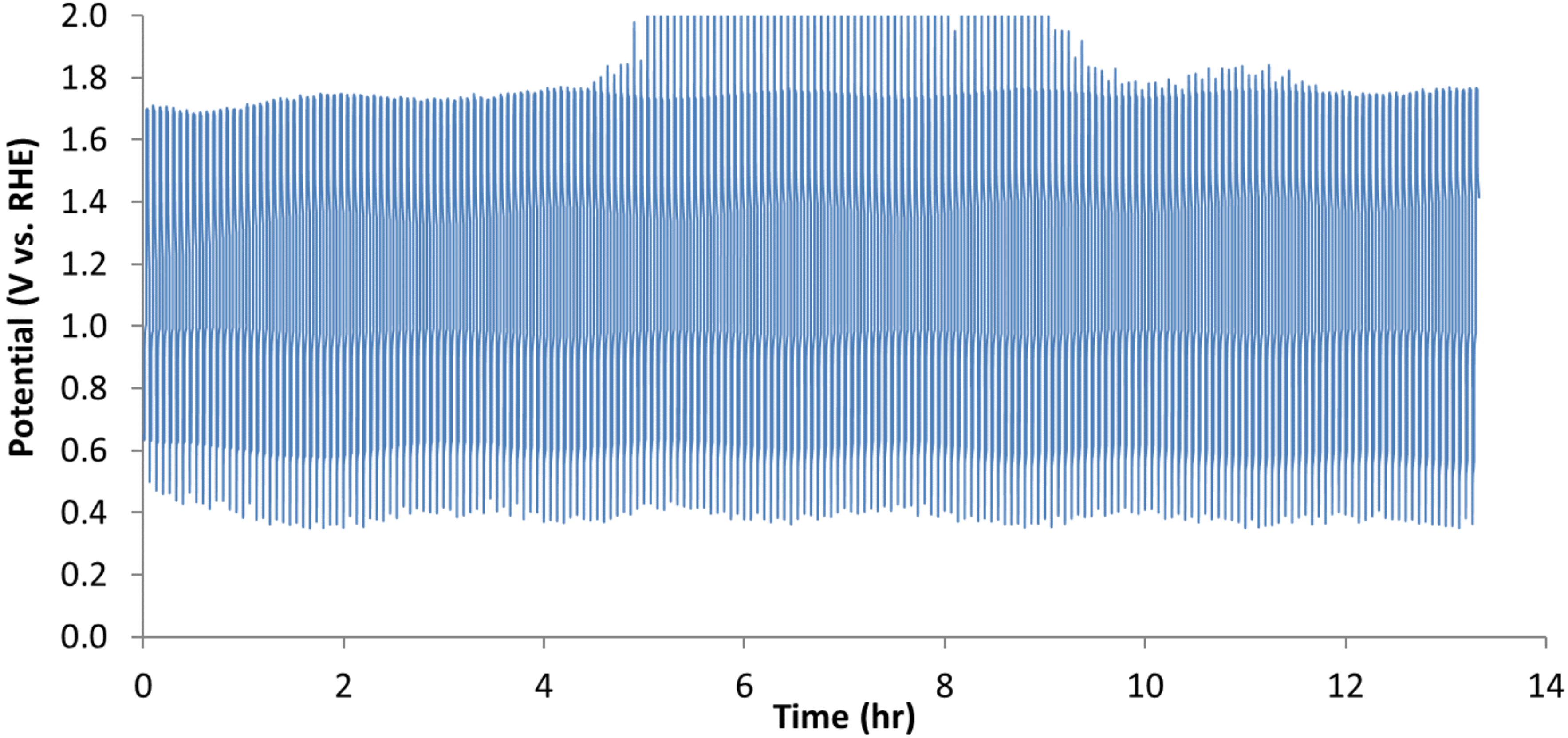
- Demonstrated stable steady-state ORR and OER performance over 100 hours:





Accomplishments

- Identified catalysts with excellent cycling durability over 200 cycles:



pH1 Matter LLC

Proposed Future Work

- Hydrogen electrode materials development
- Optimize the electrode-membrane interface
- Demonstrate 25-cm^2 cells
- Characterize the electrodes before and after cycling to better understand any degradation mechanisms
- Demonstrate durability over 1,000 cycles
- Demonstrate regenerative stack
- Perform economic analysis for a reversible AEMFC system for grid load leveling applications

pH1 Matter LLC

Summary

- Reversible fuel cells are an interesting energy storage technology for a number of applications, including grid load-leveling.
- pH Matter, Giner, and NREL are developing a reversible AEMFC; the technology could be a breakthrough for grid storage applications.
- Stable oxygen electrode materials have been demonstrated over hundreds of cycles.
- Future work aims to achieve performance and durability at 25-cm^2 single cell and 50-cm^2 5-cell stack level.

Contact Info

Paul Matter, PhD

President / Founder

1275 Kinnear Rd.

Columbus, OH 43212

Phone: 614-484-5038, ext. 4

Email: info@phmatter.com

Web: www.phmatter.com