Energy Materials Network
U.S. Department of Energy

HydroGEN
Advanced Water Splitting Materials

High Efficiency PEM Water Electrolysis

Kathy Ayers

November 15, 2017

HydroGEN Project Kickoff

NREL NATIONAL RENEWABLE ENERGY LABORATORY | BERKELEY LAB | Sandia National Laboratories | INL Idaho National Laboratory | Lawrence Livermore National Laboratory | SRNL

HydroGEN Kick-Off Meeting

High Efficiency PEM Water Electrolysis

Kathy Ayers, Proton OnSite

Iryna Zenyuk, Tufts University; Karren More, ORNL

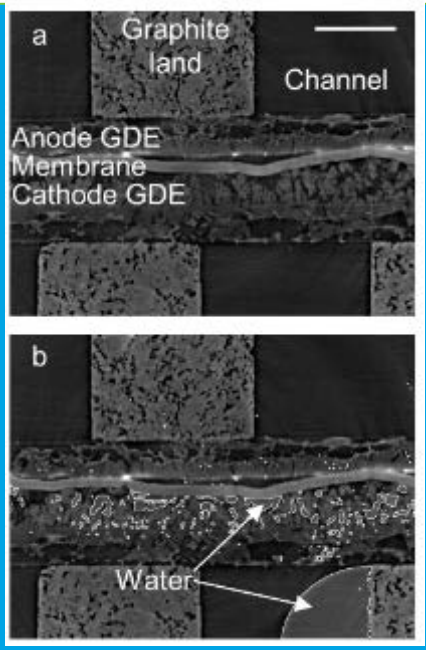
Award #	EE0008081
Year 1 Funding	$0.25M

Project Vision

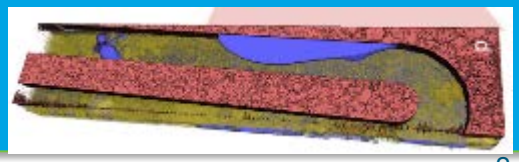
We are solving the cost barriers for PEM electrolysis by integrating advanced cell designs, materials and fundamental characterization of performance

Project Impact

The anticipated impact of Phase I is to define a reliable MEA configuration with high efficiency



Example of tomography and colored liquid water image



Innovation and Objectives

Project history

Thinner membranes and alternate catalysts have shown promise for stable operation of PEM electrolyzers at improved efficiency. This project integrates components together, while leveraging fundamental characterization to push design limits.

Proposed targets

Metric	State of the Art	Proposed
Membrane thickness	*175 microns*	*50 microns*
Operating temperature	*58°C*	*80-90°C*
Cell Efficiency	*53 kWh/kg*	*43 kWh/kg*

Barriers

- Long term durability: understand degradation through accelerated tests and fundamental characterization
- Higher defect sensitivity with adv. materials and operation: refine cell design and characterize in situ

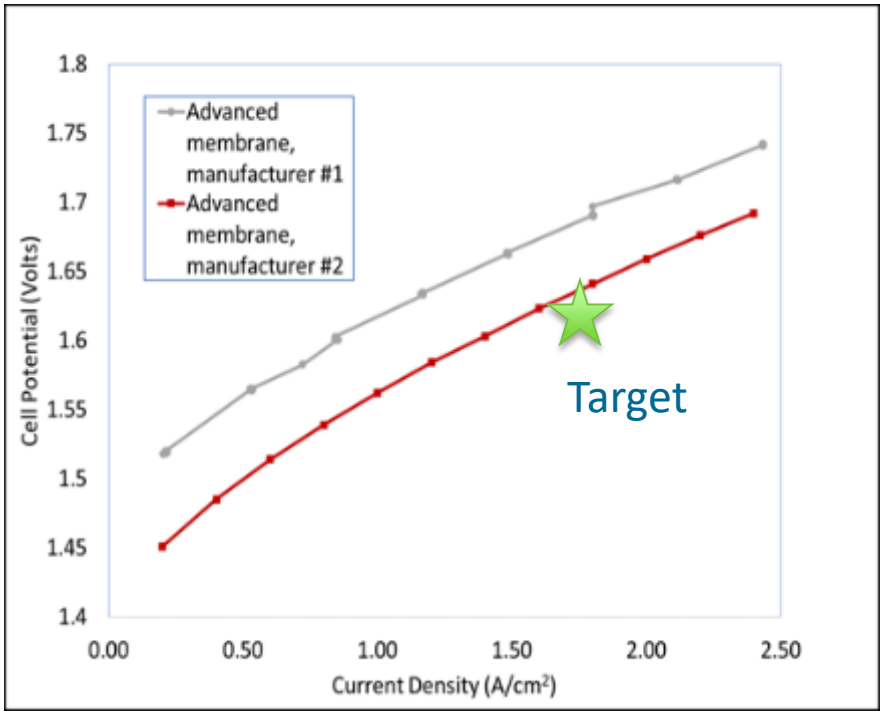
Partnerships

Iryna Zenyuk, Tufts: In situ tomography to characterize layers and water distribution

Karren More, ORNL: TEM of platinum group metal migration

Technology Innovation

- PEM electrolysis has the potential for significant efficiency improvement – challenge is integrating what we know
- Project combines promising directions in multiple areas
  - Catalyst composition
  - Stable 3-D structures
  - Thinner membranes
  - Robust manufacturing
  - Optimized interfacial layers
- Fundamental characterization
  - Water transport
  - Catalyst migration



Effective Leveraging of the EMN Resource Nodes: LBNL/NREL

- Fundamental characterization of catalyst and membrane
  - Activity screening and hydration modeling/measurement
  - Characterization of catalyst in situ/ex situ with operation
- Component characterization/manufacturing
  - High throughput catalyst deposition methods
  - Segmented cell development
- Held kickoff meeting with project and Node partners 10/17

Project Tasks: BP1

Task 1: Membrane Processing: Demonstrate operability of thin membranes at 80-90°C

1. Characterize chemical, mechanical, and electrochemical properties
2. Measure dimensional changes and hydrodynamic forces on adjacent components vs. hydration conditions

Task 2: Advanced MEA Fabrication: Characterize MEAs fabricated via ultrasonic spray internally and externally

1. Develop formulation and deposition parameters
2. Characterize water distribution through X-ray tomography

Task 3: Advanced Catalyst: Develop stable high activity alloy for OER

1. Synthesize alloyed and high surface area materials
2. Microscopy and performance characterization

Task 4: Program Management: Ensure work is coordinated towards targets

High Level Milestones

BP 1 (12 months) Milestones	Quarter
Develop project target tracking sheet based on preliminary data and define baseline current hydrogen costs	1
Demonstrate MEA performance of 1.85V with N117 at 80C	2
Quantify water distribution in operating cell with XRT	3
Complete membrane mechanical testing vs. hydration condition and evaluate options for downselect	3
Demonstrate 1.8A/cm^2 at 1.7V for advanced MEA	4 (go/no go)

Team and Roles – Core Team

- Kathy Ayers: Proton/Project PI: Overall technical oversight and point person for communication with DOE
- Chris Capuano: Program Manager: high level oversight, budget management
- Judith Manco: Senior Chemical Engineer: ink formulation, catalyst synthesis, process development for MEA
- Luke Wiles: Chemical Engineer: electrode manufacturing support, cell testing
- Eric Scheuing: Mechanical Engineer: testing support, mechanical improvements to cell, coordination of membrane mechanical characterization
- Iryna Zenyuk: Tufts PI: X-ray tomography measurements and interpretation
- Karren More: ORNL PI: Measurement of PGM distribution in membranes after operation

Team and Roles – EMN Nodes

- Ahmet Kusoglu: LBNL: Characterization of membrane hydration and ionomer behavior
- Adam Weber: LBNL: Multi-scale/water transport modeling
- Francesco Toma: LBNL: Electrochemical AFM to monitor catalyst dissolution in situ
- Nem Danilovic: LBNL: Support across nodes, electrolyzer expertise
- Guido Bender: NREL: Segmented cell development for electrolysis
- Mike Ulsh: NREL: ink formulation for high speed coating, initial feasibility for manufacturing approaches
- Shaun Alia: NREL: RDE of experimental OER catalysts
- Bryan Pivovar: NREL: Membrane fundamentals

Next Steps

- Plan testing matrix
- Set up cost models for baseline
- Procure materials for catalyst synthesis
- Procure manufactured materials