NREL
Transforming ENERGY

International Meeting on Membrane Electrode Assembly Quality Control for Electrolysis and Fuel Cells: Welcome & Overview

Meeting Co-hosts:

Michael Ulsh, National Renewable Energy Lab

Michael Hahn, DOE Hydrogen & Fuel Cell Technologies Office

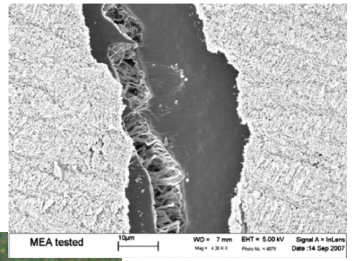
Meeting Series Co-organizers:

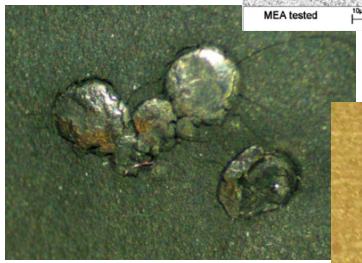
Francois Girard, NRC-Canada

Ulf Groos, Fraunhofer ISE

May 5-6, 2021

Background





REVIEW

doi:10.1038/nature11115

Electrocatalyst approaches and challenges for automotive fuel cells

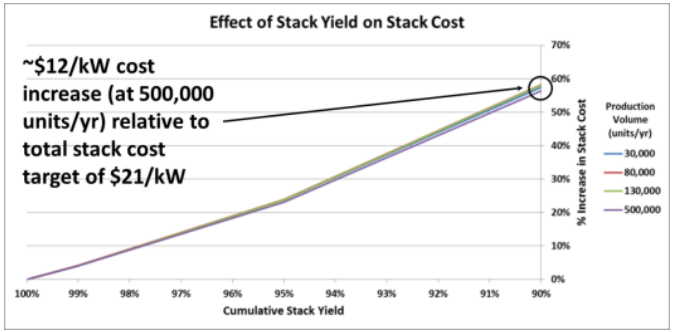
Mark K. Debe[1]

- Mark Debe's seminal paper on challenges for automotive fuel cells – addresses many aspects of high-volume manufacturing, including QC
- "Manufacturing rates need to approach several MEAs per second"
- "High-volume roll-to-roll widths up to a meter in width should be possible… ten MEAs across the web width, each measuring 10 cm x 30 cm, line speeds of 20 m/min…"
- "These MEAs have to be made with extraordinary quality control (one fatal MEA defect in 30,000 MEAs for 1% stack failures)"

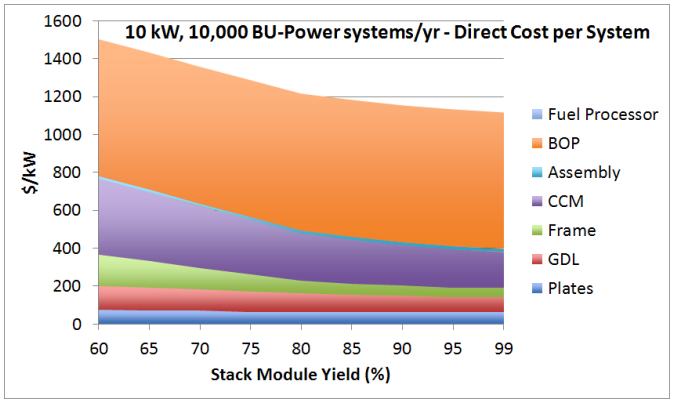
Background

There's a strong consensus that this is important…

- 2020 DOE Hydrogen Program Plan: "…R&D efforts can help **achieve economies of scale** in manufacturing… key opportunities include: Technologies for **in-line diagnostics and quality control/quality assurance**; Sensors and other technologies to **reduce manufacturing defects** in high-throughput production…"
- Path to hydrogen competitiveness (Hydrogen Council, January 2020)
  - "Our findings suggest that **scale-up will be the biggest driver of cost reduction, notably in the… manufacturing of system components**. This will deliver significant cost reductions…"
- HFTO FOA 2229: H2@Scale New Markets, Topic 1, Electrolyzer Manufacturing R&D
  - "Other innovative manufacturing approaches such as… **advanced real-time metrology techniques for QC/QA also have potential to enable overall system cost reductions**."
  - "Developing best practices for… **quality control, in situ diagnostics/inspection (at required production rates, in-line), reducing reject rates, addressing non-uniformities**…"



Strategic Analysis, Inc., NREL



LBNL

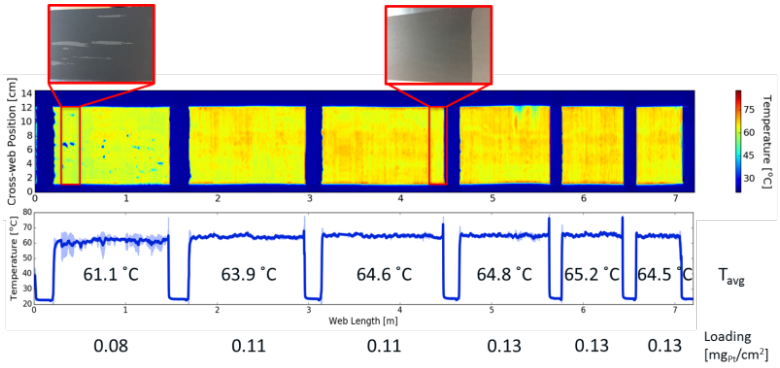
Background

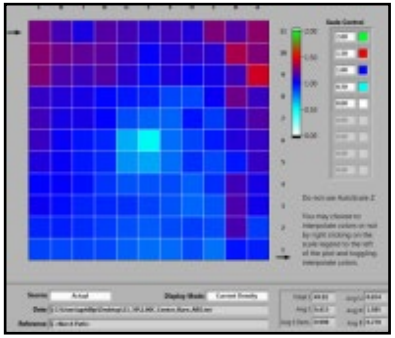
HFTO has supported a broad activity at NREL & LBNL

- Development of unique in situ tools to study the effects of defects
- Development and demonstration of in-line QC techniques
- Testbeds at scales relevant to industry
- Integrated modeling effort to guide experimentation
- Relevant to fuel cells and electrolysis

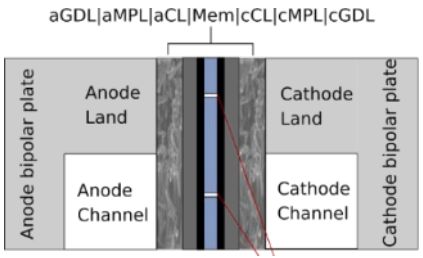
Testbeds at relevant scale

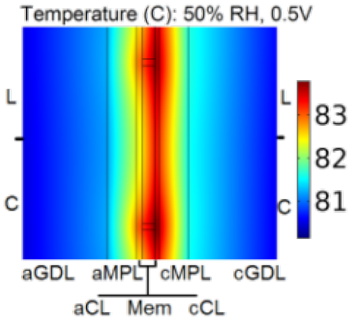
In-line QC tool development

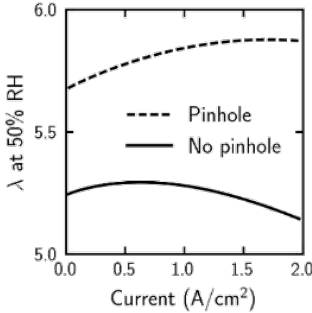




Spatial in situ tools



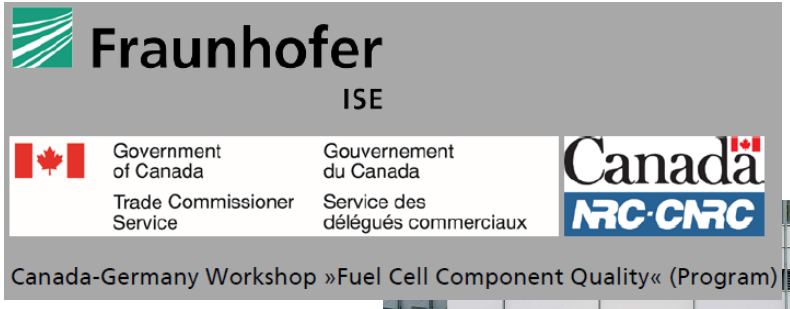




Modeling the impact of pinholes

International Workshop Series

- Canada (NRC) and Germany (ISE) led the way establishing the international workshop series on QC
- 4 international meetings so far
- Industry, academia, research institute, government participation
  - Europe, North & South America, Asia, Africa
- Focus on fuel cells
- Key learnings on needs, challenges, current capabilities, collaborative ideas
  - Outcome: broadly collaborative review paper in J. Power Sources



Meeting Objectives

- Review and discuss the outcomes of the prior QC workshops related to fuel cells, and provide opportunity for industry and stakeholders to comment
- To add low-temperature electrolysis (LTE) MEA materials to the scope of the workshop series and begin to compare and contrast LTE QC needs with those for fuel cells
- To prioritize QC needs and to output information in a format that can inform HFTO programmatic RD&D decisions
- Scope
  - Membranes, decals, electrodes, GDLs, sub-assemblies (CCM, GDE, etc.), full MEAs, other cell components
  - Low-temperature PEM fuel cells and electrolyzers
  - Ex situ methods (in-line, off-line), in situ studies to understand defects

Note on Sensitive Information

- The intension of the meeting is to discuss QC technology needs in a pre-competitive environment
- We understand that aspects of manufacturing can be and are highly sensitive
- In the past workshops, as well as in past DOE activities, we have found that open discussion of QC needs and barriers has been possible without the inclusion of specific material, structure, cell or stack information that could be sensitive
- Please do not discuss proprietary or sensitive information
- A public report of meeting discussion and outcomes is planned
- Discussion during the meeting WILL BE recorded. However, the recording WILL NOT be posted publicly – it will only be used to ensure we've captured all of the discussion and information for the report.
  - Individual statements will not be attributed

Agenda: Wednesday, May 5

10:00-10:15	Welcome and overview of workshop	Michael Ulsh, NREL Michael Hahn, HFTO
10:15-10:30	DOE Hydrogen & Fuel Cells Technology Office (HFTO) introductory comments	Jesse Adams, Technology Acceleration Program Manager, HFTO
10:30-11:00	Industry commentary on fuel cell quality control (QC) status/challenges (15 min talks)	Erin Setzler, Gore Michael Yandrasits, 3M
11:00-11:20	Overview of Fraunhofer ISE (ISE) activities	Matthias Klingele, Fraunhofer ISE
11:20-11:40	Overview of National Research Council-Canada (NRC) activities	Francois Girard, NRC
11:40-12:00	Overview of National Renewable Energy Laboratory (NREL) activities	Michael Ulsh, NREL
12:00-12:15	Break	
12:15-1:00	Description and outcomes of prior QC workshops (fuel cells)	Ulf Groos, Fraunhofer ISE Francois Girard, NRC Riny Yuan, NRC Ken Shi, NRC
1:00-1:45	Open discussion/feedback on prior findings for fuel cells	Michael Ulsh, NREL
1:45-2:00	Open discussion on prioritization of QC R&D needs for fuel cells	Michael Ulsh, NREL
	Adjourn	

Agenda: Thursday, May 6

10:00-10:10	**Welcome and reminder of 2nd day agenda**	**Michael Ulsh, NREL Michael Hahn, HFTO**
10:10-10:30	**Report-out on day 1 findings and prioritization**	**Peter Rupnowski, NREL**
10:30-10:50	**Introductory discussion/comparison of low-temperature electrolysis (LTE) and fuel cell membrane electrode assembly (MEA) materials, structures, and operating conditions and implications for QC**	**Guido Bender, NREL**
10:50-11:30	**Industry commentary on LTE QC status/challenges (20 min talks)**	**Adam Paxson, Plug Power Chris Capuano, Nel**
11:30-11:45	**Break**	
11:45-12:45	**Open discussion on LTE QC needs and challenges**	**Michael Ulsh, NREL**
12:45-1:15	**Open discussion on prioritization of LTE QC R&D needs**	**Michael Ulsh, NREL**
1:15-1:45	**Wrap-up discussion: collaboration opportunities and ideas, final comments**	**Michael Hahn, HFTO**
	Adjourn	

Webex Meeting Logistics

- Please keep yourself muted during the presentations to avoid background noise.
- Unless speaking, please turn off your webcam to avoid bandwidth issues.
- This meeting is being recording for our records only and will not be distributed publicly.
- During the open discussion portion of the meeting, you have the ability to unmute yourself and join the conversation. Please introduce yourself when you do. If you feel comfortable doing so, please turn on your webcam while speaking. Please mute yourself again and turn off your webcam when you are done speaking.
- You are welcome to type any questions or comments into the chat box. We will be monitoring this and will address these when possible.
- If you are experiencing audio difficulties, try changing your audio settings to go through your phone. This often cuts down on audio issues that may be related to bandwidth concerns.
- If you have any technical questions or concerns, please contact ryan.ingwersen@nrel.gov

Thank You

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Hydrogen is one part of a broad portfolio of activities

HFTO addresses the challenge of moving today's technologies from the laboratory to high-volume, pre-commercial manufacturing by investing in research, development and demonstration activities to drive down the cost of hydrogen and fuel cell systems, as well as enable wide-scale hydrogen production and utilization in the United States.

www.hydrogen.energy.gov

"It will be essential to develop industrial-scale techniques, processes, and facilities for manufacturing hydrogen-related technology components and systems at large volumes" – Department of Energy Hydrogen Program Plan, 2020

Background

- These needs are represented in HFTO's Multi-year Research, Development, and Demonstration plan (Manufacturing section*)
  - It's DOE's "what our projects should be addressing" document

Task 5: Quality Control and Modeling and Simulation	
5.1	Establish models to predict the effect of manufacturing variations on MEA performance. (4Q, 2016)
5.2	Demonstrate improved sensitivity, resolution, and/or detection rate for MEA inspection methods. (4Q, 2016)
5.3	Validate and extend models to predict the effect of manufacturing variations on MEA performance. (4Q, 2017)
5.4	Design and commercialize an in-line QC device for PEMFC MEA materials based on NREL's optical reflectance technology. (4Q, 2017)
5.5	Develop correlations between manufacturing parameters and manufacturing variability, and performance and durability of MEAs. (4Q, 2018)
5.6	Demonstrate methods to inspect full MEAs and cells for defects prior to assembly into stacks in a production environment. (4Q, 2018)
5.7	Develop areal techniques to measure platinum (and other catalyst metals) quantitatively in an MEA. (4Q, 2018)
5.8	Implement demonstrated in-line QC techniques on pilot or production lines at PEMFC MEA material manufacturers. (4Q, 2020)
5.9	Develop imaging-based methods for 100% inspection of PGM loading in electrodes. (4Q, 2020)

Task 1: Membrane Electrode Assemblies	
1.1	Develop processes for highly uniform continuous lamination of MEA components. (4Q, 2017)
1.2	Develop processes for direct coating of electrodes on membranes or gas diffusion media. (4Q, 2017)
1.3	Develop continuous MEA manufacturing processes that increase throughput and efficiency and decrease complexity and waste. (4Q, 2017)
1.4	Demonstrate processes for direct coating of electrodes on membranes. (4Q, 2019)
1.5	Demonstrate processes for highly uniform continuous lamination of MEA components. (4Q, 2019)
1.6	Develop fabrication and assembly processes for PEMFC MEA components leading to an automotive fuel cell stack that costs $20/kW. (4Q, 2020)

** 2015*

Background

Manufacturing Fuel Cell Manhattan Project Presented by the Benchmarking and Best Practices Center of Excellence, ACI Technologies, 2012.

Inspection Goals:

- Implementable in an in-line fashion
- Non-destructive
- Areal (100% inspection or nearly so)
- Rapid measurement and data processing