V.J.3 New MEA Materials for Improved DMFC Performance, Durability, and Cost

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- University of Florida, Gainesville, FL
- Northeastern University, Boston, MA
- Johnson Matthey Fuel Cells, Swindon, UK

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Objectives

Optimize the functionality and internal water recovery features of the UNF passive water recovery membrane electrode assembly (MEA) to facilitate overall system simplicity, thereby increasing power and energy density and lowering the cost at the system level to address DOE's fuel cell target goals for consumer electronics applications.

- Optimize the UNF MEA design:
  - Improve durability and reliability.
  - Increase power and energy density.
  - Lower the cost.
- Develop commercial production capabilities:
  - Scale up the process to commercial batch operation level.
    - Improve performance and lower reproducibility.
    - Lower cost.
- Increase catalyst stability and lower loading:
  - Increase the anode catalyst stability.
  - Lower MEA cost.

Technical Barriers

This project addresses the following technical barriers for consumer based electronic applications of less than 50 W from the Fuel Cells section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability

(B) Cost

(C) Performance

Technical Targets

TABLE 1. Status and System Level Targets for Passive Water Recovery MEAs

Characteristic	Units	UNF 15 WDP3 2008 Status	DOE 2010 Target
Specific Power[a]	W/kg	35	100
Power Density[a]	W/L	48	100
Energy Density	W-hr/L	250 (1 x 100 ml)[b] 396 (1 x 200 ml)[b]	1,000
	W-hr/kg	155 (1 x 100 ml)[b] 247 (1 x 200 ml)[b]	N/A
Lifetime[c]	Operating Hours	1,000 hrs in single cell	5,000
Cost	$/Watt	11 (est. in volume)	<3

[a] Beginning of life, 30°C, sea level,50% relative humifdity, excluding hybrid battery, power module alone
[b] Normalized from DP3 data from 150 ml cartridge to either 100 ml or 200 ml for comparison purposes
[c] Lifetime measured to 80% of rated power

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Approach

The passive water recovery MEA (Figures 1 and 2) has been specifically designed for operation in the UNF system. This design incorporates the novel passive water recycling features of the MEA. The water recycling features enable significant simplification and miniaturization of the fuel cell at the system level, thus optimizing the resulting power and energy density. This approach optimizes the key attributes of the MEA and improves the system performance and durability. The scaling up of the manufacturing process for the MEA layers enhances both performance and reliability and reduces the overall cost. Our approach to improve

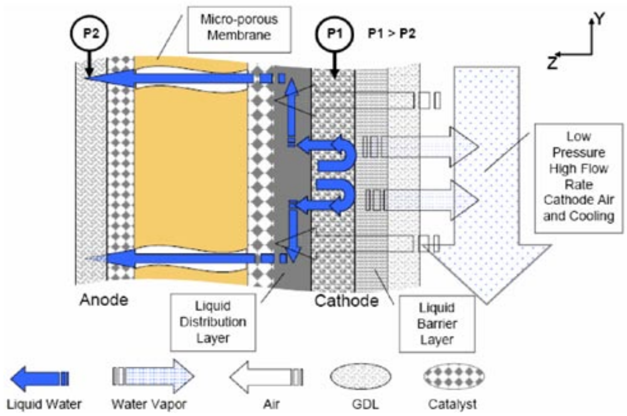

FIGURE 1. Water Transport Characteristics Optimized to Internally Recycle Water to Anode Compartment

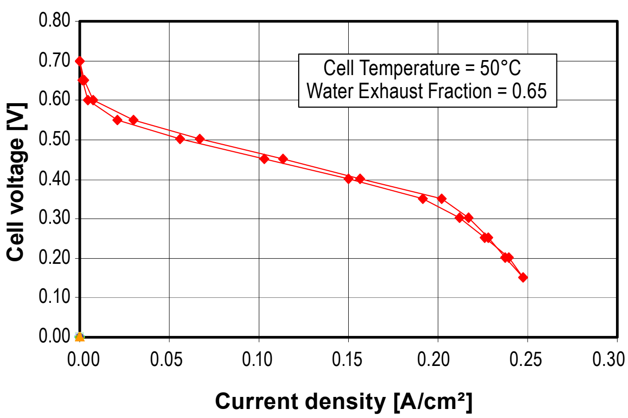

FIGURE 2. Baseline MEA performance with passive water recovery enables system simplification and recovery of both product water and electo-osmotic drag water in the MEA.

the anode catalyst structure to enhance the stability of the ruthenium improves the overall durability in direct methanol fuel cell (DMFC) applications. With our partners we will optimize the manufacturing process for preparing the passive water MEAs. We will move beyond the prototype operation by developing a batch manufacturing process which will improve the MEA-to-MEA reproducibility, increase the durability, and reduce the cost of the overall MEA. Our approach includes an evaluation of the MEA produced at both the single cell and the system level against system operating conditions required for a small compact DMFC system developed in a related project at UNF. This process will include controlled warm-up and shut-down, standard operation and storage, and some anticipated out-of-operating specification conditions.

Accomplishments

The project was initiated in January 2010. Major accomplishments to date:

- Designed baseline MEA to produce passive water recovery under system operating conditions designed to optimize the overall system performance.
- Developed a Pt_8Ru_8Au on carbon catalyst that looks promising for improved ruthenium stability, with 99% of the surface area retention after long-term chronoamperometry compared to 88% retention of the surface area for a commercially available reference sample.

Future Directions

- Continue catalyst development and characterization:
  - Optimize and scale up of the anode catalyst with improved ruthenium stability.
  - Integrate improved catalyst into the passive water recovery MEA design.
  - Increase testing of high stability anode catalysts under system operating conditions, including long-term catalyst durability testing under operating and storage conditions.
- Improve manufacturing techniques for the liquid barrier layer:
  - Optimize steps to improve manufacturing process and lower sample to sample variation.
  - Test process variability and the effects on the MEA reproducibility and durability.
- Optimize MEA structure:
  - Develop optimized MEA coating and fabrication to produce lower sample to sample variability and improve performance.
  - Incorporate improved catalyst and liquid barrier layers to optimize performance and durability.
- Single cell and stack testing:
  - Measure performance and durability under system type operating conditions including start up, shut down, and storage conditions.