V.C.8 Corrugated Membrane Fuel Cell Structures

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Subcontractors:
- Graftech International Holdings Inc., Parma, OH
- General Motors Corporation, Flint, MI

Project Start Date: September 1, 2010
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Fiscal Year (FY) 2011 Objectives

To pack more membrane active area into a given geometric plate area. Thereby allowing both targets of power density and platinum utilization to be achieved:

- To demonstrate a fuel cell single cell (50 cm^2) with a 2-fold increase in the membrane active area over the geometric area of the cell by corrugating the membrane electrode assembly (MEA) structure.
- Incorporation of an ultra-low Pt-loaded corrugated MEA structure in a 50 cm^2 single cell that achieves the DOE 2015 target of 0.2 gram Pt/kW, while simultaneously reaching the targets of power density:
  - 1 W/cm^2 at full power
  - 0.25 W/cm^2 at ¼ power

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(B) Cost (lower cost metal gas diffusion layer [GDL], lower plate/GDL manufacturing costs)

(C) Performance (high power density with low Pt-loaded MEAs)

TABLE 1. Progress Toward Meeting DOE Fuel Cell Technical Targets

Comparison of Fuel Cells with Different GDLs			
Fuel Cell Data			
Build Date	**3/24/2011**	**4/8/2011**	**4/11/2011**
Build Number	**1720XL100-1No16**	**1720XL100-1No18**	**1732XL100-1No20**
CCM[1] Lot #	**1720**	**1720**	**1732**
Membrane Type	**XL 100**	**XL 100**	**XL 100**
Manufacturer	**Ion Power**	**Ion Power**	**Ion Power**
Membrane + Catalyst Thickness	**2.5 mil (both side catalyst layer)**	**2.8 mil (both side catalyst layer)**	**2.6 mil (both side catalyst layer)**
GDL Anode Side	10BC 1 layer	2x Pt-coated Ti fine screen 1x Pt-coated Ti coarse screen[2]	6 layers Pt-coated Ti fine screen (with 5 welding points)
GDL Cathode Side	10BC 1 layer	2x Pt-coated Ti fine screen 1x Pt-coated Ti coarse screen[2]	10BC 1 layer
Comments of the GDL Packs		The coarse screen is between the fine screen (with 5 welding points)	
Compression Torque Applied to the Fixation Screws	12 inch pounds	11 inch pounds	11 inch pounds

[1]CCM – catalyst-coated membrane
[2]GDL screen packs: The coarse screen is between the fine screen (with 5 welding points)

FY 2011 Accomplishments

Corrugated GDL structure formed with expanded Ti metal screen. Fine 2 mil screen for good diffusion and contact, with course 10 mil thick screen for strength. (See Figures 1 and 2, respectively.)

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Introduction

The traditional proton exchange membrane (PEM) fuel cell stack with its bipolar plates, MEAs, seals and end-plates has been the dominant method of construction of multi-kW fuel cells for the past 40 years. Smaller sub-watt and portable applications have explored novel cell design variations such as "jelly roll" concepts but none have been able to achieve the power density of the traditional stacked plate design.

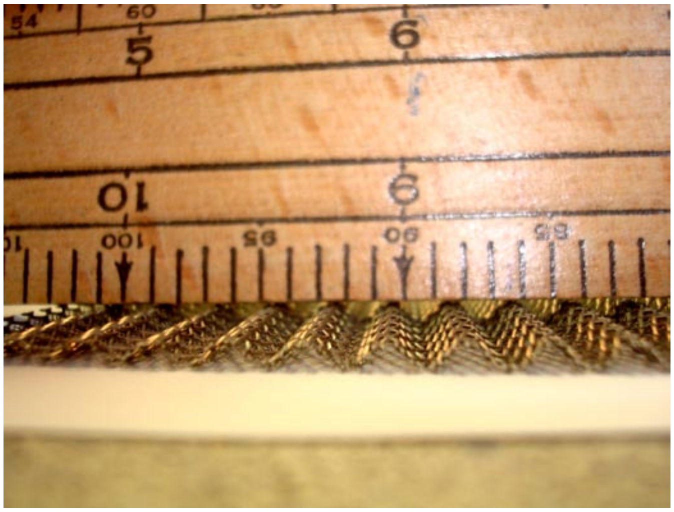

FIGURE 1. Titanium Screen as a Gas Diffusion Layer

FIGURE 2. Corrugated Gas Diffusion Layer Structure

The primary reason for this is the efficient collection of the current and the compact packing of the MEAs.

Approach

At the present time one of the most challenging aspects of traditional PEM fuel cell stacks is the difficulty to achieve the platinum catalyst utilization target of 0.2 g Pt/kWe set forth by DOE [1,2]. Good catalyst utilization can be achieved with state-of-the-art CCMs when ultra-low catalyst loadings (<0.1 mg/cm^2) are used at lower current. Unfortunately when ultra-low loadings are used, the peak power density is lower as compared to conventional loadings [3]. Thus, a larger total active area and a larger bipolar plate are needed, which results in a lower overall stack power density. Therefore, this project aims to realize both the Pt utilization targets as well as the power density targets of the DOE by corrugating the fuel cell membrane electrode structure and thus packing more membrane area into the same geometric plate footprint.

A single cell 50 cm^2 fuel cell test jig (or fixture) will be designed and fabricated such that it will allow testing of both conventional flat MEAs with conventional flow fields and the corrugated single-cell assemblies fabricated. Furthermore, the jig will also allow the hand assembly of each of the individual components. Inserts will be created to generate straight through flow and serpentine flow in both flat and corrugated MEA architectures so that water, thermal and gas flow management issues can be diagnosed.

Results

Results to date show that expanded titanium metal screens can be formed into corrugated structures and incorporated into an operating fuel cell. Electrical resistance of the diffusion material was measured and found to be reduced as a result of the new diffusion material. However, mass transport and water management issues were negatively impacting the results of the tests. These issues are mainly being attributed to gas flow by-passing the corrugated channels, and the large pore size of the GDLs being used. We plan to address these issues by developing more conventional GDLs in the corrugated format that contain the commonly used carbon black/poly-tetrafluoroethylene micro-diffusion layers up against the membrane to form a very fine pore structure interface to the membrane. This is the structure of the current state-of-the-art GDLs that have the proper water-managment and mass-transport requirements for high performance MEAs.

Conclusions and Future Directions

In summary, success has been made in expanded metal screen structures both in cell performance and in structures.

Future work will include: get single cell test fixture working; get corrugated Ti expanded screen GDL attached to Ti plate; demonstrate low contact resistance and good mass transport in flat Ti screen structures; and get mechanical strength modeling effort underway.

FY 2011 Publications/Presentations

1. AMR Presentation May 11, 2011.

References

1. DOE Manufacturing Workshop Web site: www.eere.energy.gov/hydrogenandfuelcells/wkshp_h2_manufacturing.html

2. HFCIT Program "Multi-Year Research, Development and Demonstration Plan", U.S. DOE Office of Energy Efficiency and Renewable Energy, February 2005. Please see: www.eere.energy.gov/hydrogenandfuelcells/mypp/

3. M.F. Mathias, et al "Two Fuel Cell Cars in Every Garage?" The ECS Interface Fall 2005, pg 24.