2012 DOE Hydrogen Program Review

Corrugated Membrane Fuel Cell Structures

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This presentation does not contain any proprietary or confidential information
Overview

Timeline
• Start: Sept 1, 2010
• End: Sept 30, 2013
• 25% Complete

Budget
• Total project funding
  – DOE share $1,651,616
  – Contractor share $507,096
• Funding received in FY11: $400,000
• Planned Funding for FY12: $300,000

Barriers
B: Costs
• Lower Metal GDL cost
• Lower Plate/GDL manufacturing costs

C: Performance
• High power density with low Pt loaded MEAs

Partners
• Project lead
  ➢ Ion Power
• Interactions/ collaborations
  ➢ General Motors
    Testing and Modeling
  ➢ GrafTech
    Graphite components
  ➢ GKD/Dexmet
    Metal screens
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 cm²) with a 2-fold increase in the membrane active area over the geometric area of the cell by corrugating the MEA structure

– Incorporation of an ultra-low Pt loaded corrugated MEA structure in a 50 cm² single cell that achieves the DOE 2015 target of 0.2 gram Pt/kW, while simultaneously reaching the power density targets:
  
  • 1 W/cm² at full power
  • 0.25 W/cm² at ¼ power
Objectives

Close-up of Flowfield Assembly and MEA
SINGLE CELL HARDWARE
Technical Accomplishments

Original Cell Design Requiring Convoluted Seals

- Anode Backing Plate
- Anode Flowfield/DM
- Cathode Flowfield/DM
- Cathode Backing Plate
- Subgasket
- MEA
Technical Accomplishments

Redesigned Cell with Molded Subgasket to Eliminate Need for Convoluted Seal

1. Anode corrugated GDL – Plate subassembly
2. Cathode corrugated GDL – Plate subassembly
3. Flowfield Backing Plates
4. Membrane Electrode Assembly with Molded Subgasket
Redesigned Cell Layout with Die Cut Seals

1. Anode Plate
2. Cathode Plate
3. Anode Spacer
4. Cathode Spacer
5. Plate to Spacer O-Ring
6. Cell Assembly
7. Anode Flow Directors
8. Cathode Flow Directors
9. Die Cut Membrane Seals
Technical Accomplishments

Anode Corrugated GDL-Plate Subassembly
Isometric View
Technical Accomplishments

Corrugated GDL-Plate Subassembly Profile View

Dime same scale

Corrugations:
- Height: 0.400
- Width: 0.325
- Distance: 2.000

Dimensions:
- Top: 0.200
- Bottom: 0.125
- Total Height: 1.743
Technical Accomplishments

Status of Single Cell Hardware

• Cell fixture is complete.
• Subgasket forming tools are complete.
• Seals and flow distributors are being fabricated.
• Checkout of fixture and testing can begin as soon as Corrugated GDL-Plate Subassembly becomes available.
Technical Accomplishments

CORRUGATED GDL-PLATE SUBASSEMBLY FORMING TOOL
Perforated GDL substrate has been compression molded to corrugated geometry. The forming tool previously described will be used to make the corrugations instead of compression molding.
Formed GrafTech Perforated GDL Substrate

Rough side of the perforated material. Notice the transition from flat material into the corrugations.

Smooth side of the perforated material. Notice the transition from flat material into the corrugations.

The flat edges of the part will allow the outside gasket to seal the perforated material in the fixture. (300 openings / cm²)
Technical Accomplishments

CORRUGATED MEMBRANE FORMING TOOL
Forming Blades

- Form Blade
- Compression Slide
- Slide Plate
- Indexing Screw
- Form Tool Base
GDL DEVELOPMENT
Technical Accomplishments

Demonstration of Microporous Layer’s (MPL) Effect Utilizing a Flat Cell Configuration:

(1) Cathode: Expanded Ti Metal Screen Pack (6 layers of 2 mil, ~2500 openings/cm² screen)
(2) Cathode: Expanded Ti Metal Screen Pack with graphite microporous layer*

*US Patent #7063913
Volumetric 3 wire mesh
Opening: 0.077 mm
   10,000 openings/cm²
Wire Diameter: 0.050mm
   SS 316L (.0019”)

- Coated in 500nm Au
- Final gold-coated screen will be convoluted using the flowfield forming fixture previously described.
- Convoluted gold-coated screen will be brazed to gold-coated flowfield backing plate
- Gold becomes brazing flux
Demonstration of metal screen with **no MPL** in a flat cell configuration

Cathode: 1 layer of gold-coated SS screen with no microporous layer

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**Technical Accomplishments**

![Graph showing voltage vs. current for different cathode configurations. The graph compares Baseline (Anode GDL: Sigracet 10BC, Cathode GDL: Sigracet 10BC) and Cathode Screen Pack with No MPL.](image-url)
Assumptions and Definitions for GM Cost Analysis of Corrugated Fuel Cell Stack

• Fuel Cell Stack Delta cost reflects changes in membrane area, platinum loading, and bipolar plate cost
• Hydrogen Fuel Delta cost reflects additional hydrogen cost over life of vehicle due to increased hydrogen crossover from the increased membrane area
• Hydrogen Storage Delta cost reflects the cost of additional onboard storage required to maintain the same range as the baseline case.
• Lifecycle Delta cost is the Fuel Cell Stack Delta cost plus the Hydrogen Fuel Delta cost plus the Hydrogen Storage Delta cost.
• First slide reflects maintaining the same areal Pt loading on the anode while second slide reflects reducing the areal Pt loading to maintain the same total Pt loading on the anode.
Delta Cost, Pt, Fuel Economy, Stack Volume vs. Pt loading (corrugated stack)

Does not include potential anode platinum thrifting.
Delta Cost, Pt, Fuel Economy, Stack Volume vs. Pt loading
(corrugated stack)

Includes Potential Anode Catalyst Thrifting

Cathode Catalyst Loading

- 25%
- 38%
- 50%
- 63%
- B/L

Cost, Pt, FE, Volume vs. Baseline

FCS Dcost, $
H2 storage Dcost, $
H2 fuel Dcost, $
Lifecycle Dcost, $
Pt savings, %
Fuel Economy D, mi/kg
Relative Stack Volume, %
Collaborations

Subcontractor
- **General Motors**: Modeling, Testing, and Jig Design

Subcontractor
- **GrafTech**: Graphite-based GDL - Plate Subassembly Development

Suppliers
- **Dexmet**: Expanded Ti metal screens and plates, in different shapes
- **GKD**: Woven SS metal screens

Vendors
- **Precious Plate, Inc.**: gold coating of metal GDL
- **Vac-Met**: metal brazing
Project Summary

• Detailed GM Lifecycle Analysis shows significant Life Cycle cost savings at a mid Pt loading and not at ultra low or not as much at baseline Pt loadings

• Small corrugation feature size requires fixturing to prototype

• Candidate GDL metal material have been found that have superior fuel cell performance and can be formed into the desired structures
Proposed Future Work

• Work with fixture to form corrugated GDL-Plate subassemblies, both in GrafTech graphite and brazed GKD SS

• Incorporate into single cell for first fuel cell testing