DOE Hydrogen Program

2012 DOE Hydrogen Program Review

Corrugated Membrane Fuel Cell Structures

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Ion Power, Inc (Prime)

GM & GrafTech (Sub-Contractors)

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Project ID # FC090

This presentation does not contain any proprietary or confidential information

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Overview

DOE Hydrogen Program

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

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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 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 power density targets:
  - 1 W/cm^2 at full power
  - 0.25 W/cm^2 at ¼ power

Objectives

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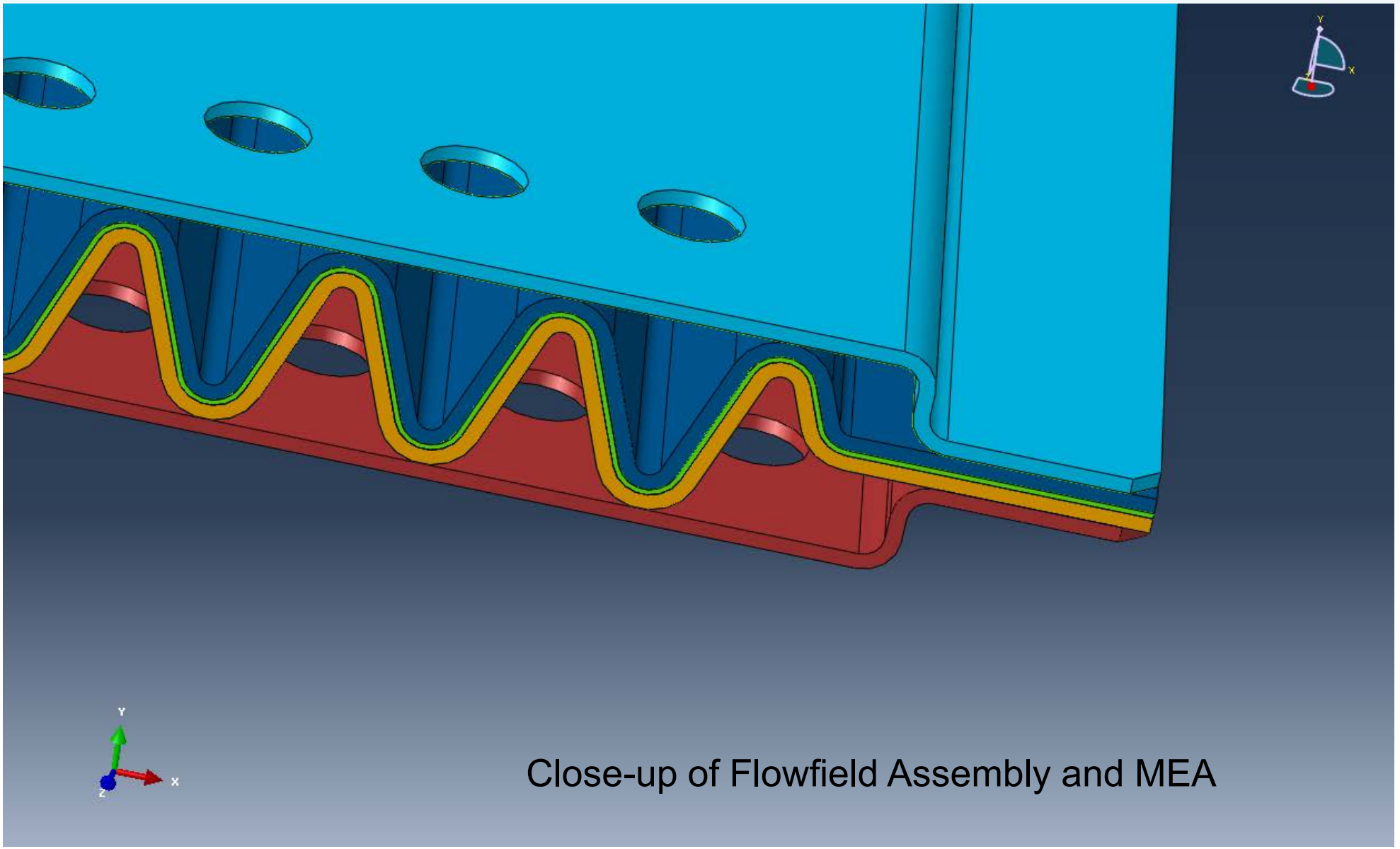

Close-up of Flowfield Assembly and MEA

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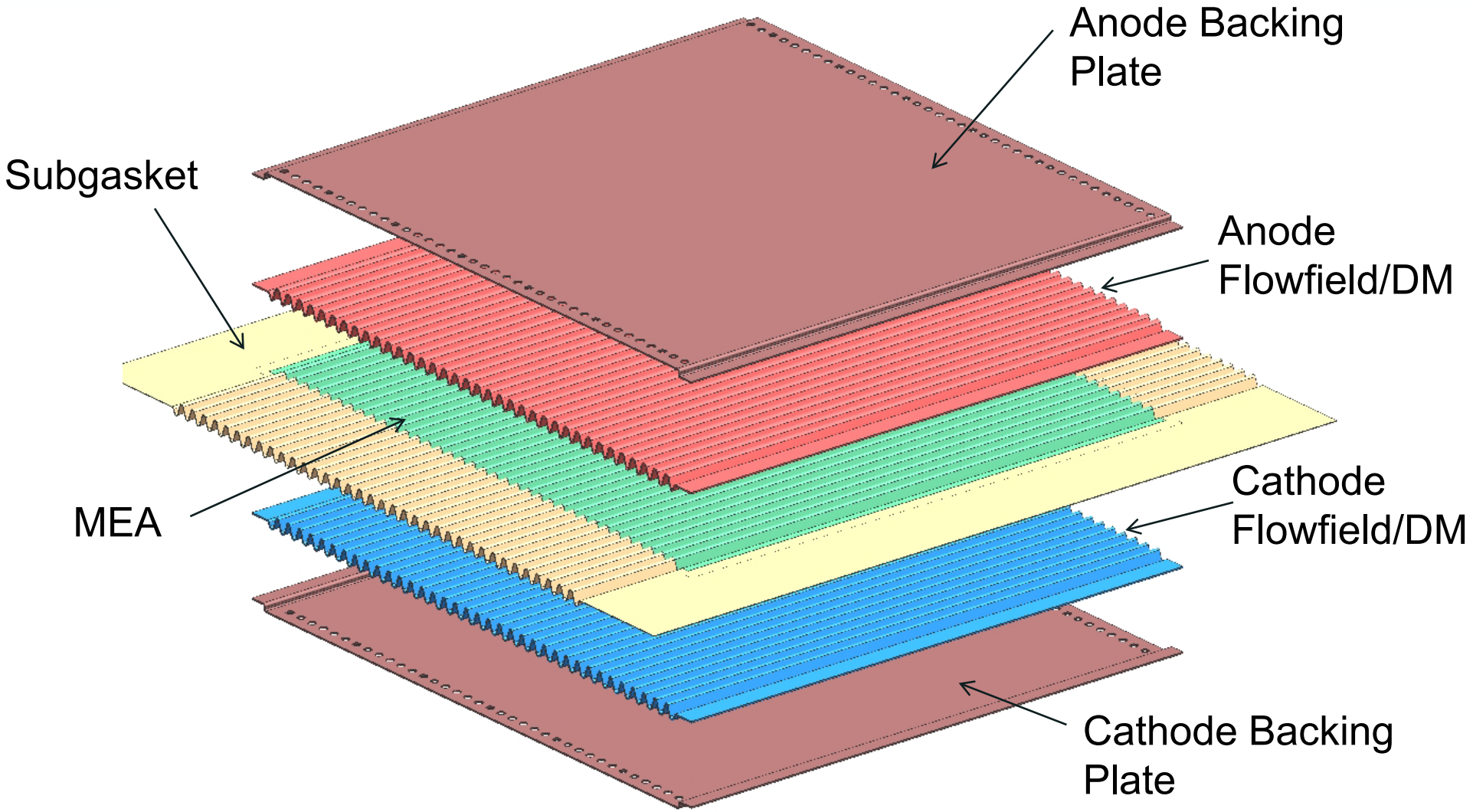
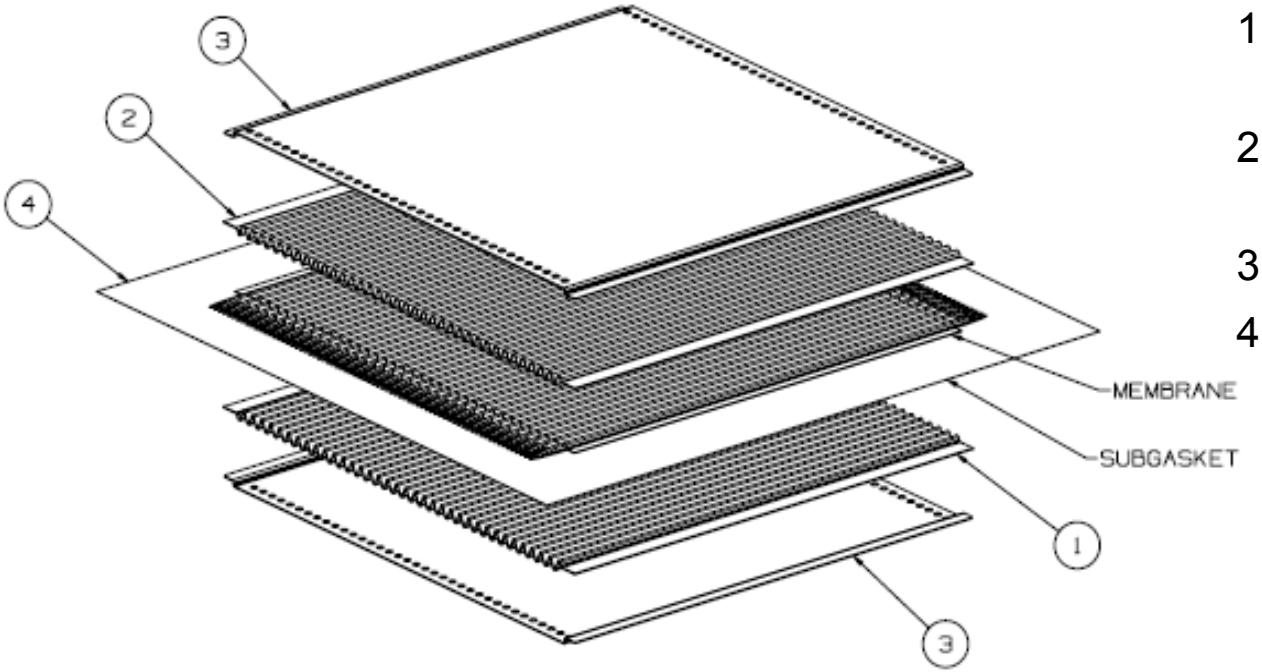
SINGLE CELL HARDWARE

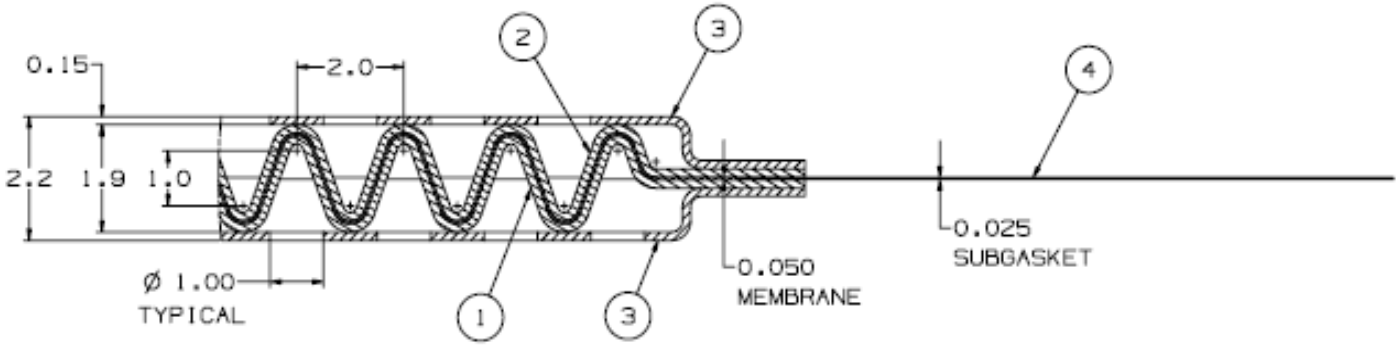
Original Cell Design Requiring Convoluted Seals



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



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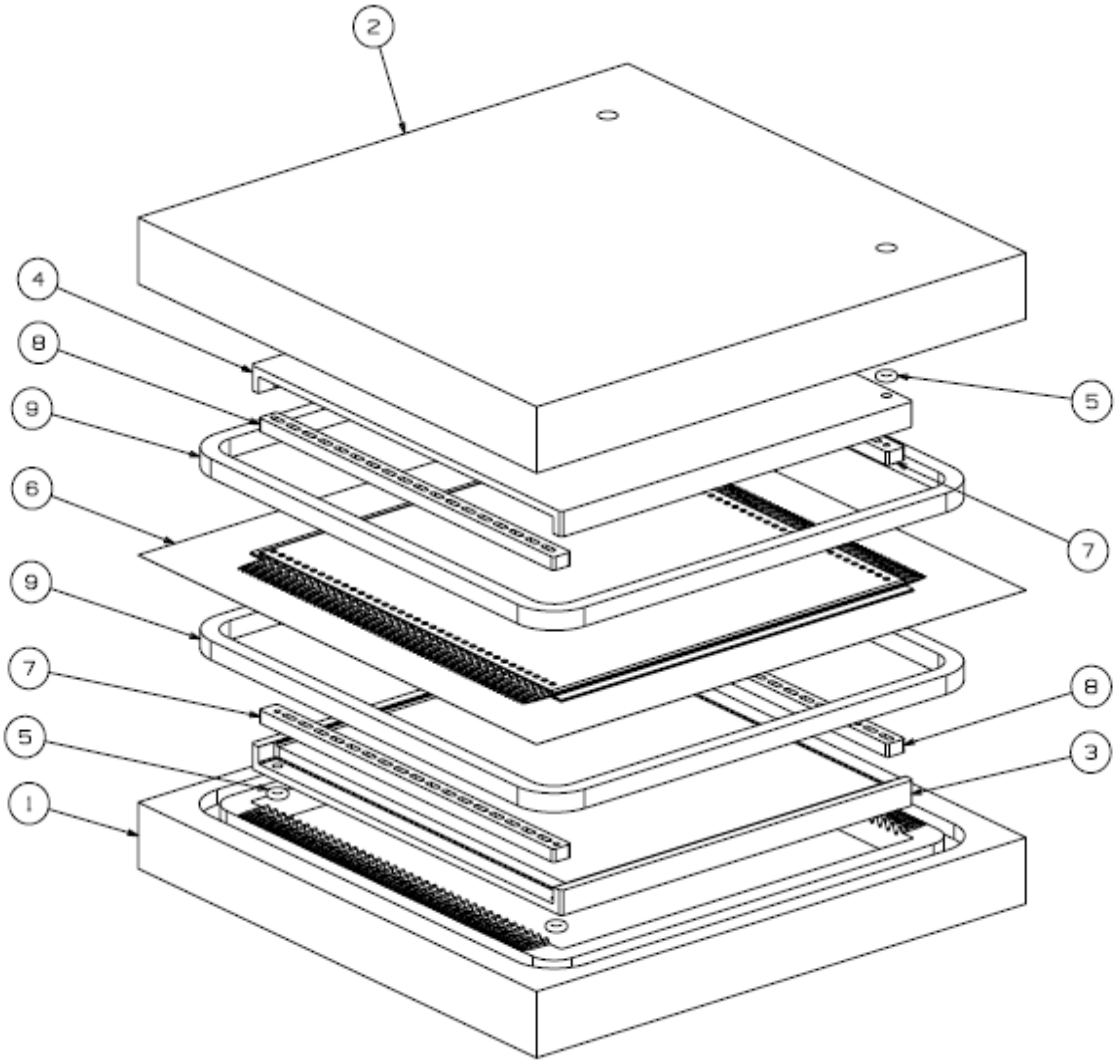
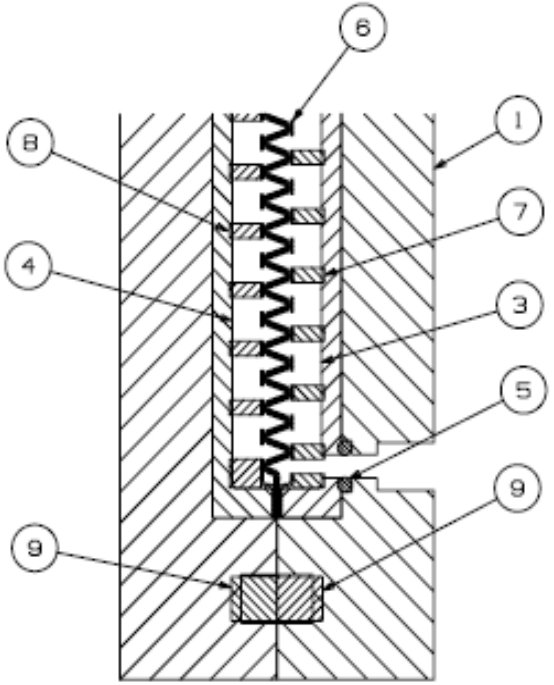
Redesigned Cell Layout with Die Cut Seals

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





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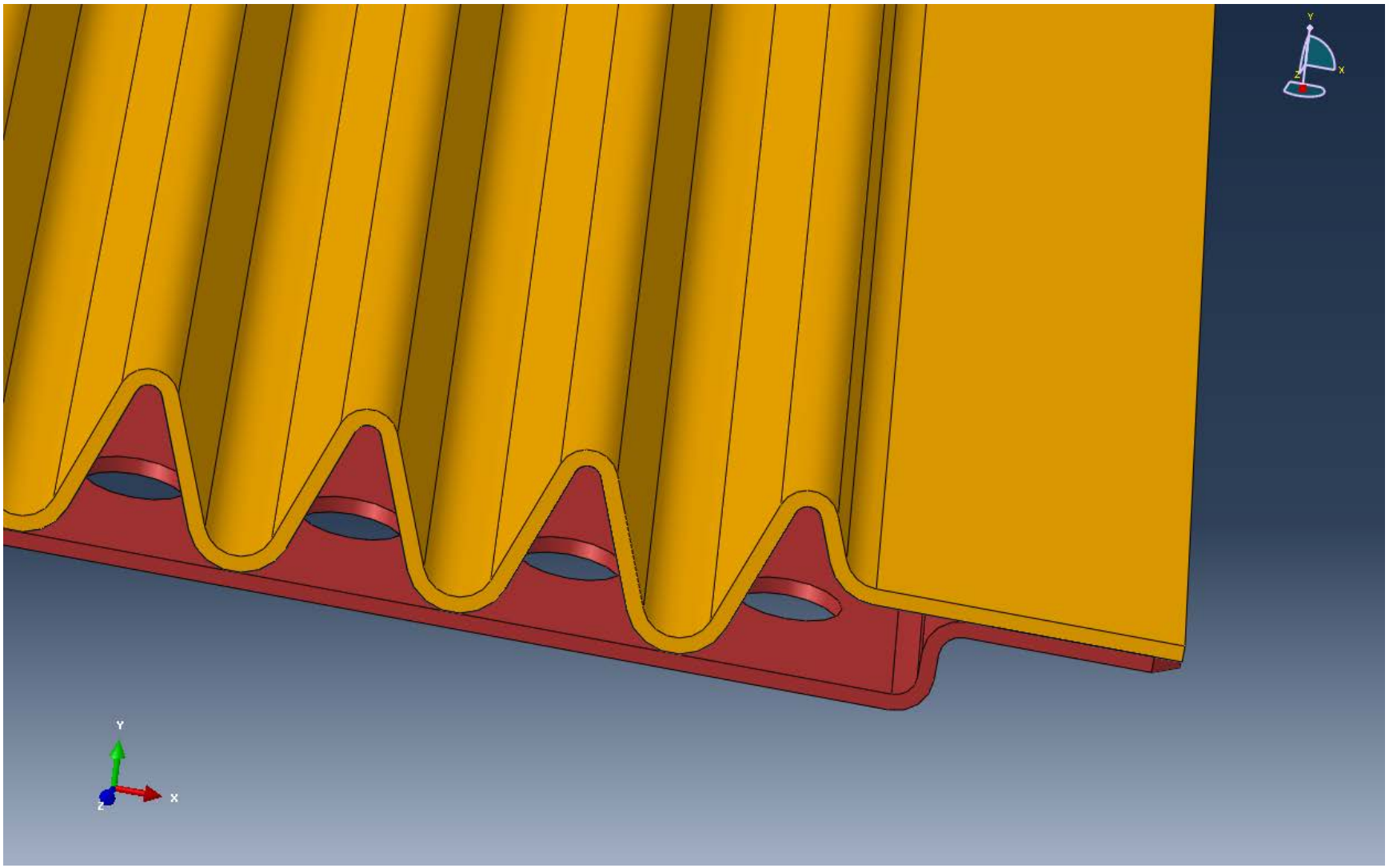
Anode Corrugated GDL-Plate Subassembly Isometric View



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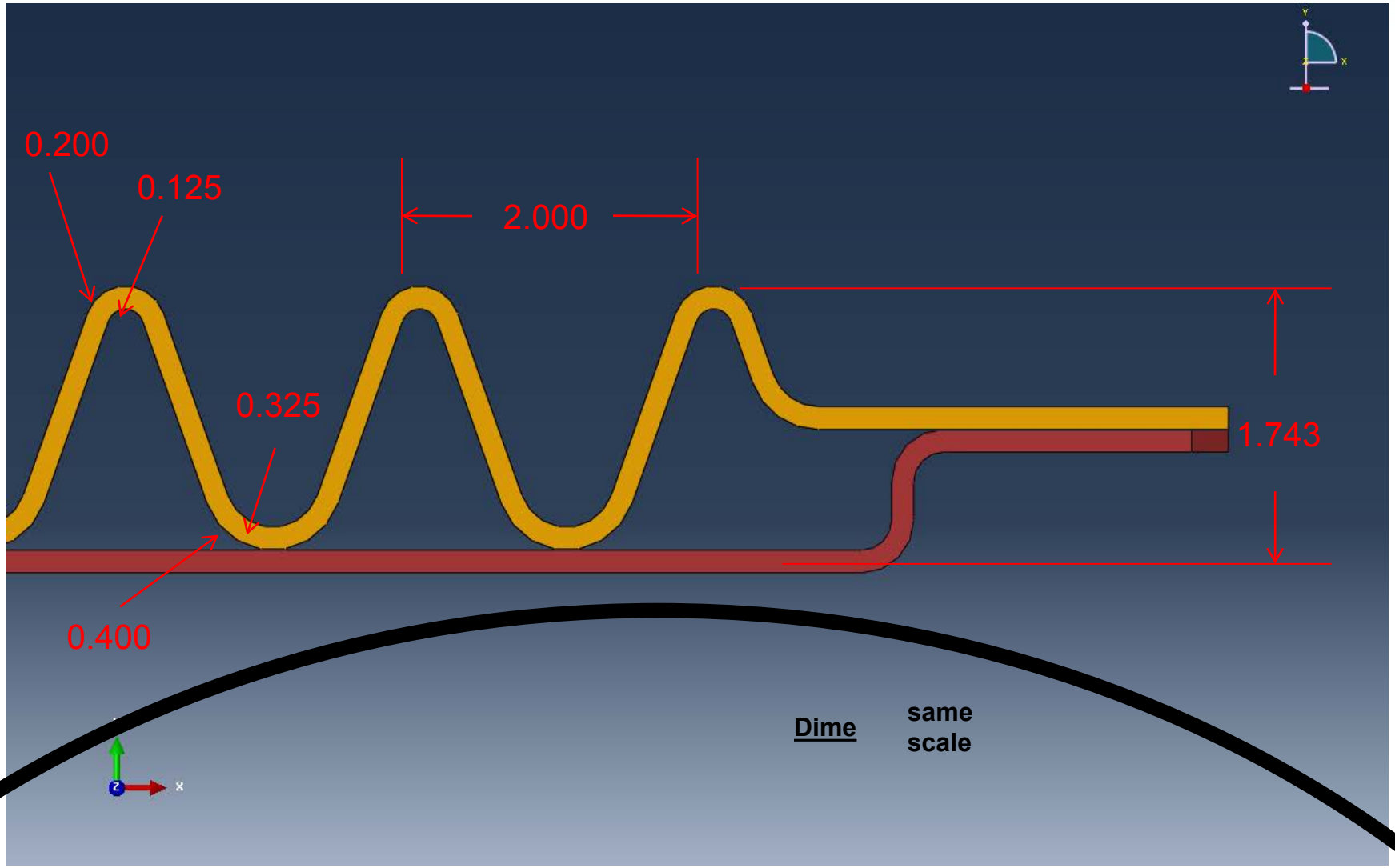
Corrugated GDL-Plate Subassembly Profile View



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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.

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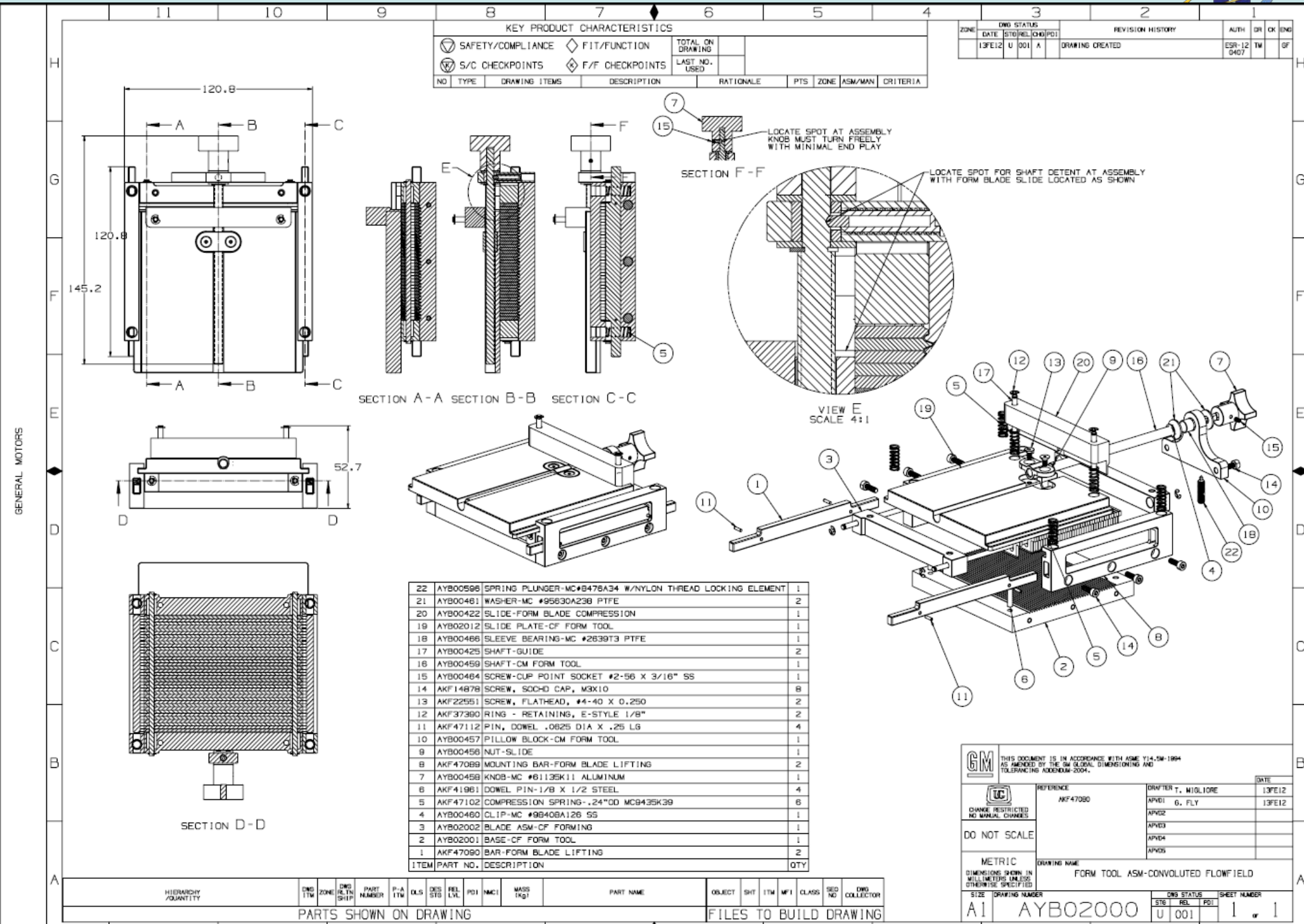
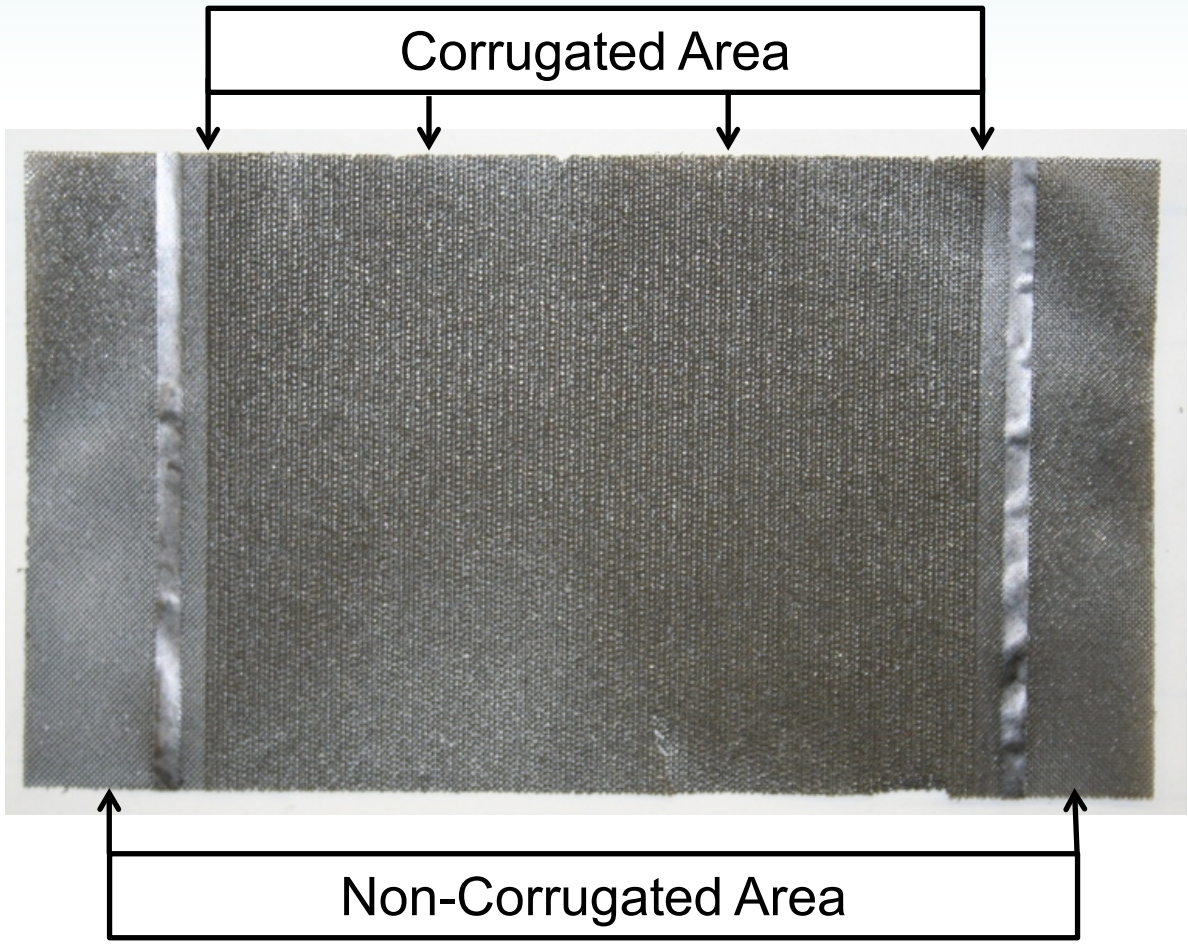
CORRUGATED GDL-PLATE SUBASSEMBLY FORMING TOOL

Technical Accomplishments



Formed GrafTech Perforated GDL Substrate



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.

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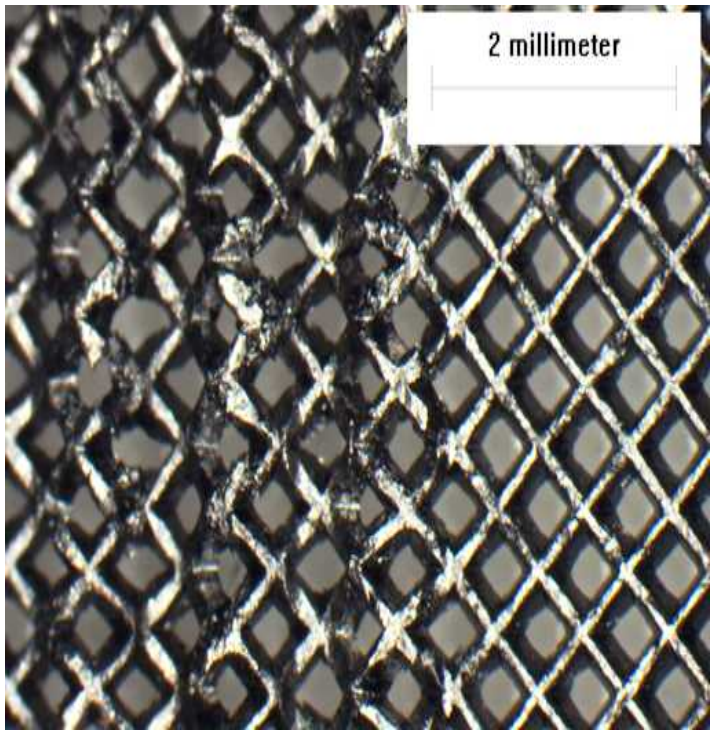
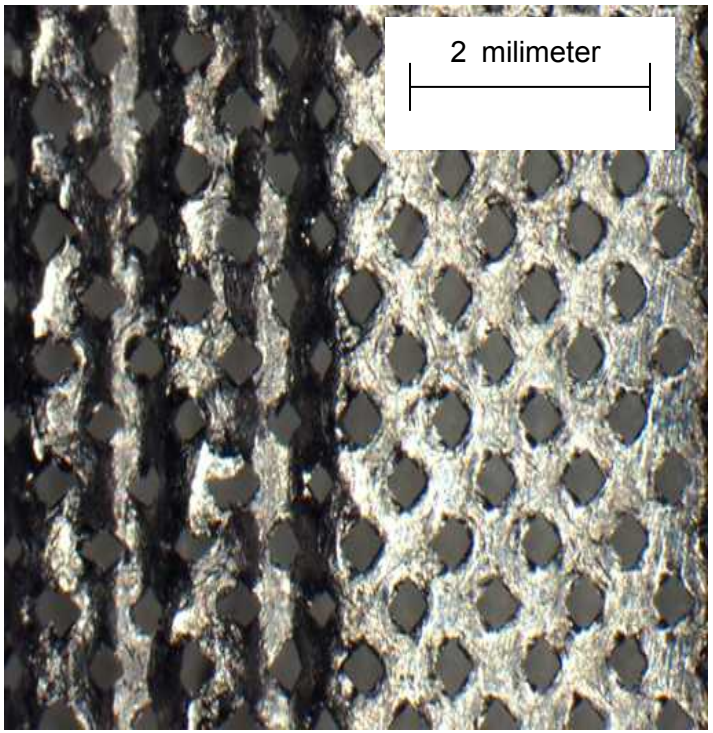
Formed GrafTech Perforated GDL Substrate

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 / cm^2)

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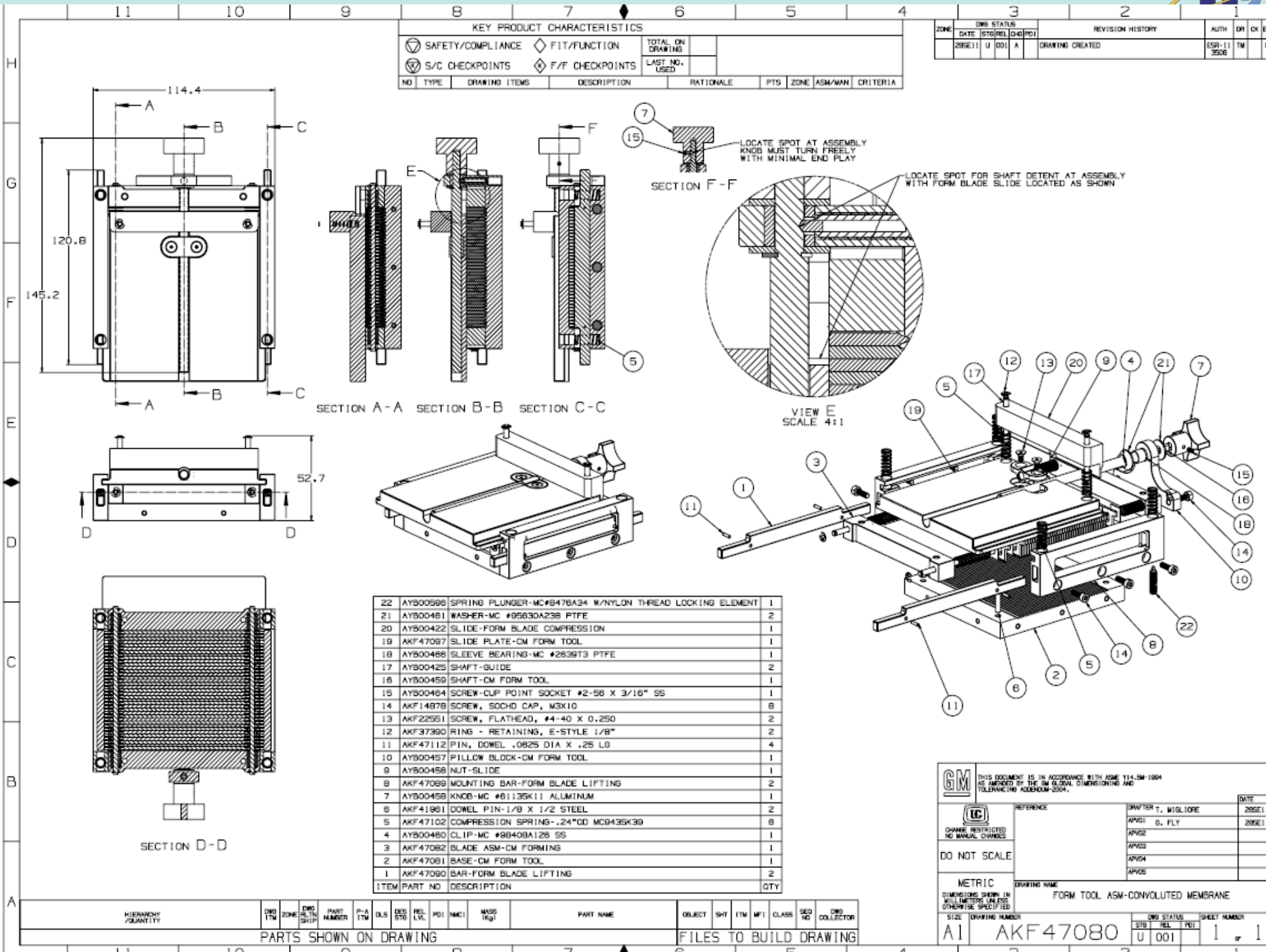
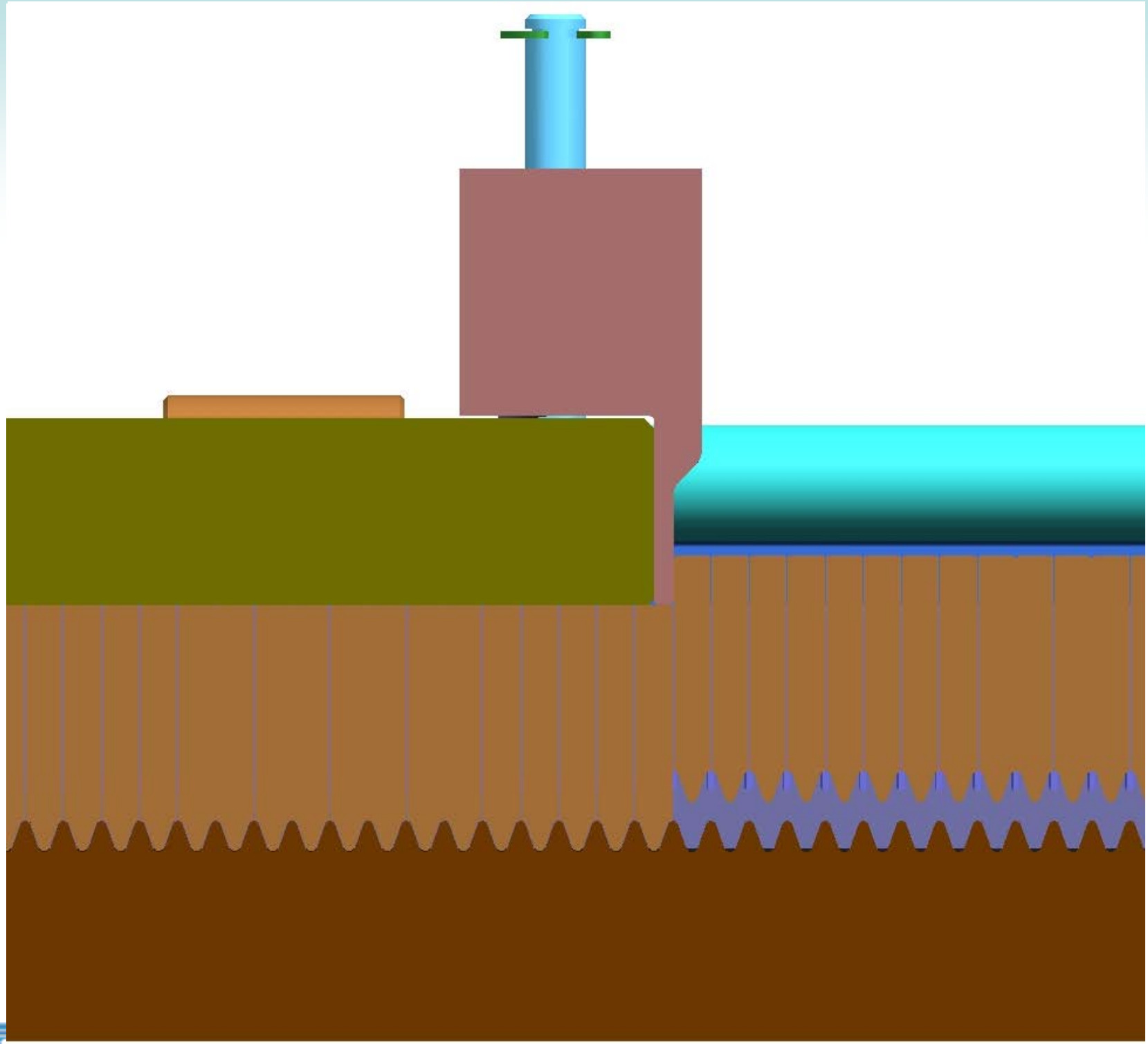
CORRUGATED MEMBRANE FORMING TOOL

Technical Accomplishments





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GDL DEVELOPMENT

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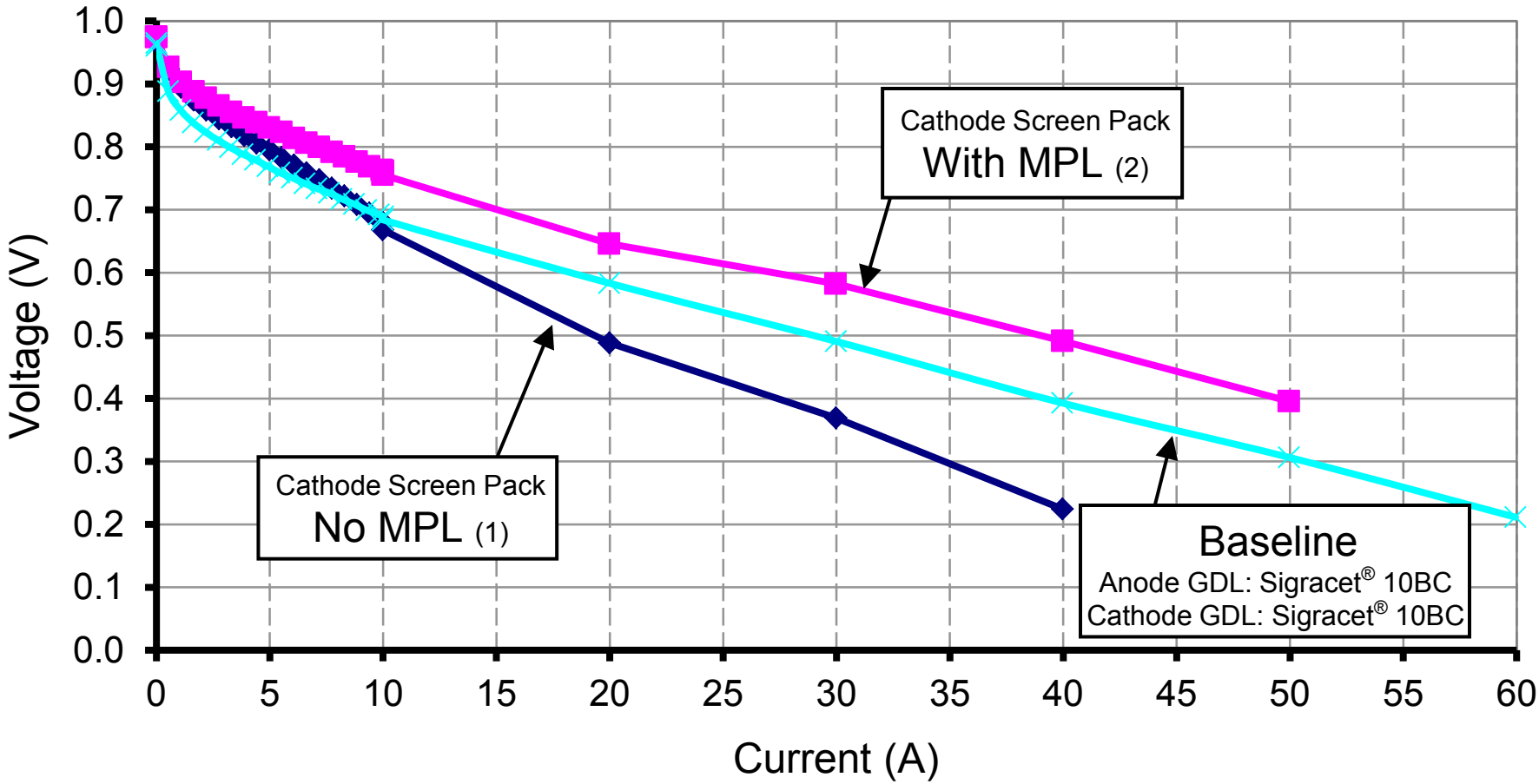
Demonstration of Microporous Layer's (MPL) Effect Utilizing a Flat Cell Configuration:

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



*US Patent #7063913

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GKD Stainless Steel Woven Mesh Specifications

Volumetric 3 wire mesh

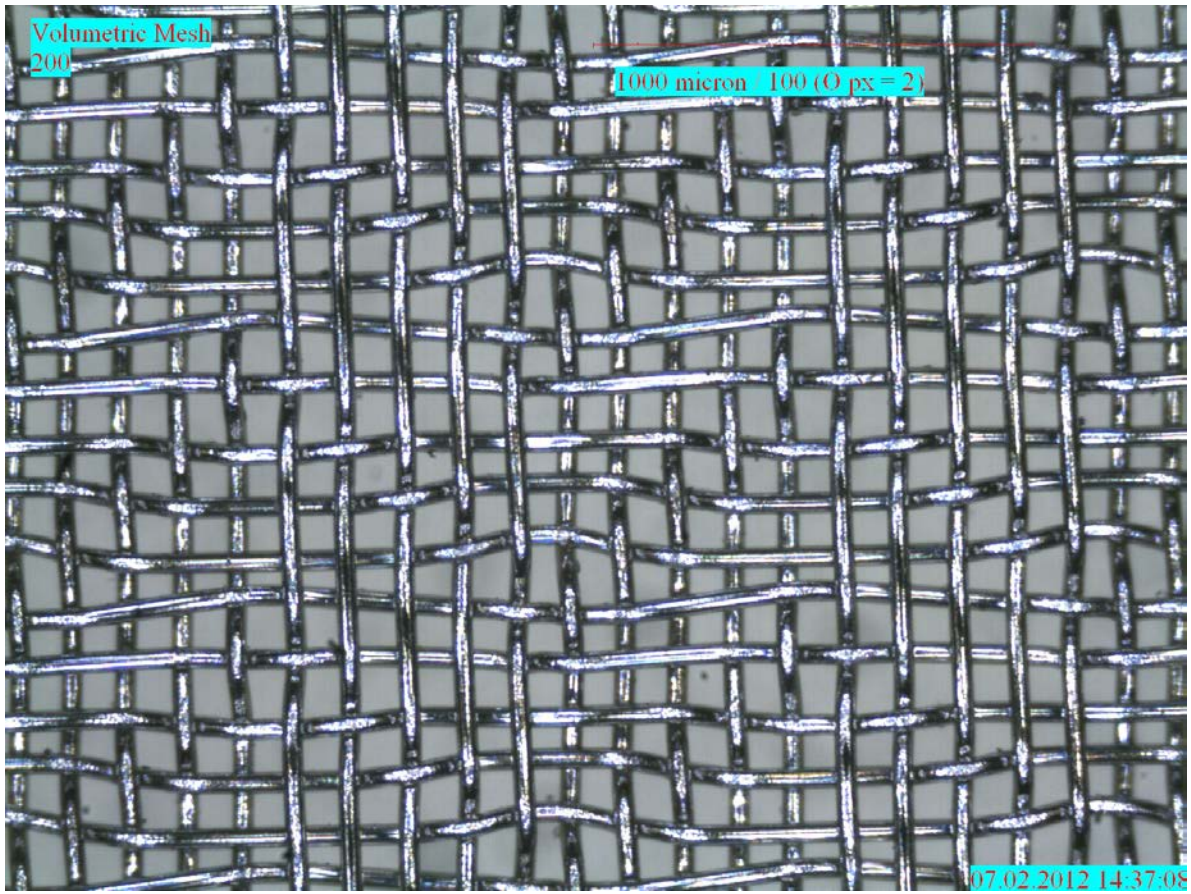
Opening: 0.077 mm

10,000 openings/cm^2

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



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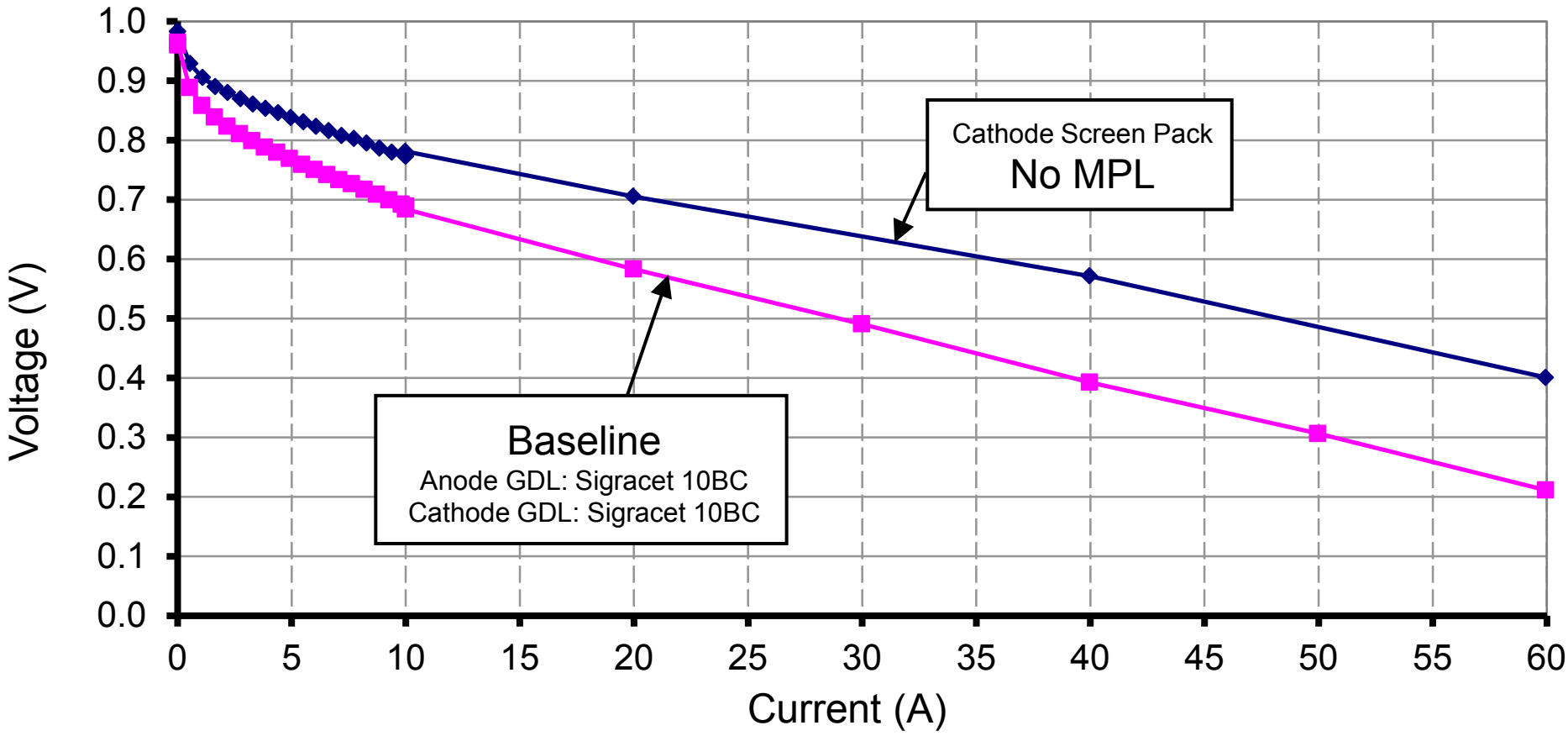
Demonstration of metal screen with no MPL in a flat cell configuration

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



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Assumptions and Definitions for GM Cost Analysis of Corrugated Fuel Cell Stack

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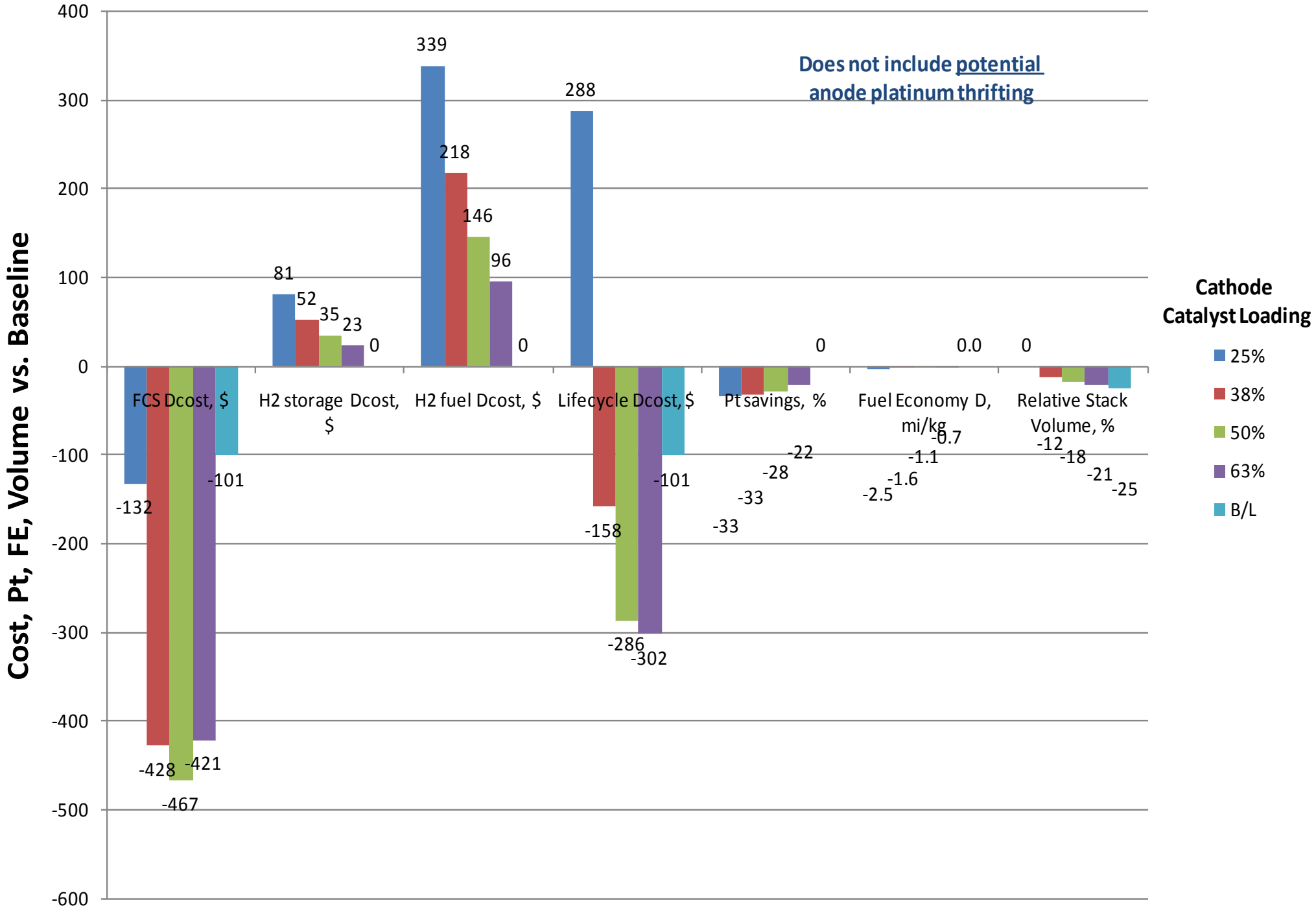
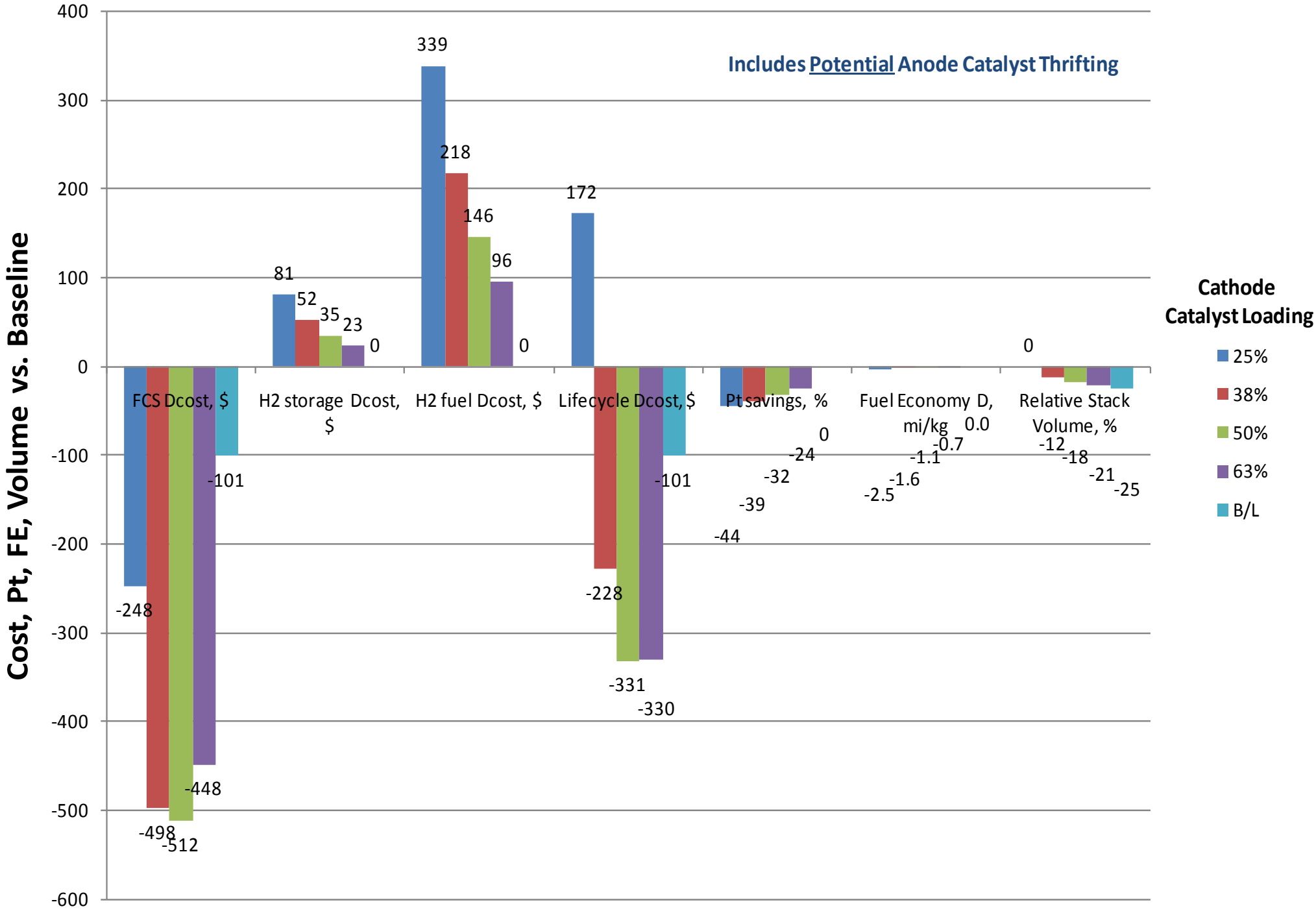
- Fuel Cell Stack Delta cost reflects changes in membrane area, platinum loading, and bipolar plate cost
- Hydrogen Fuel Delta cost reflects additional hydrogen cost over life of vehicle due to increased hydrogen crossover from the increased membrane area
- Hydrogen Storage Delta cost reflects the cost 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)



Delta Cost, Pt, Fuel Economy, Stack Volume vs. Pt loading (corrugated stack)



Collaborations

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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