Cost Reduction Strategies for PEM Electrolysis

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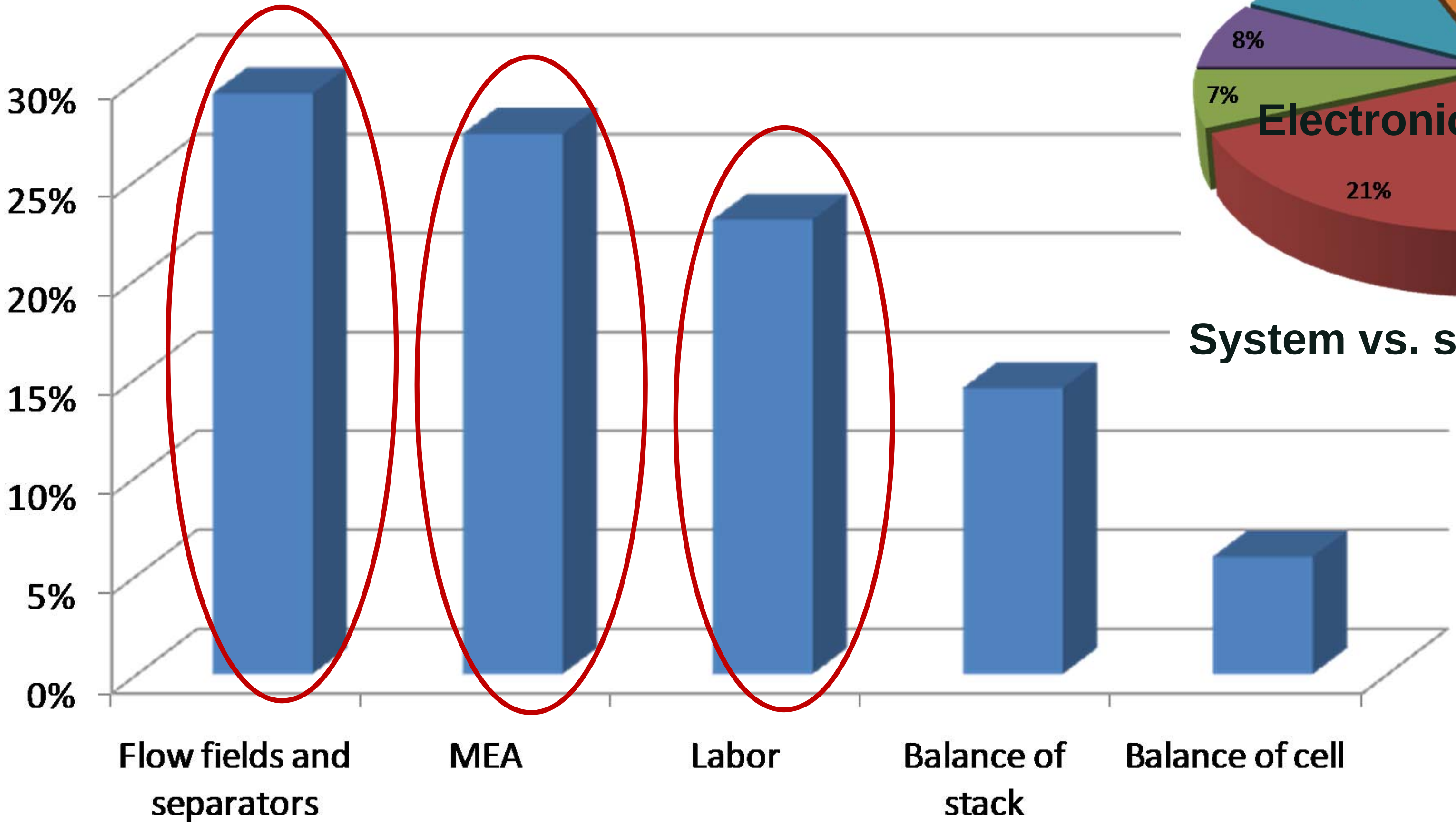
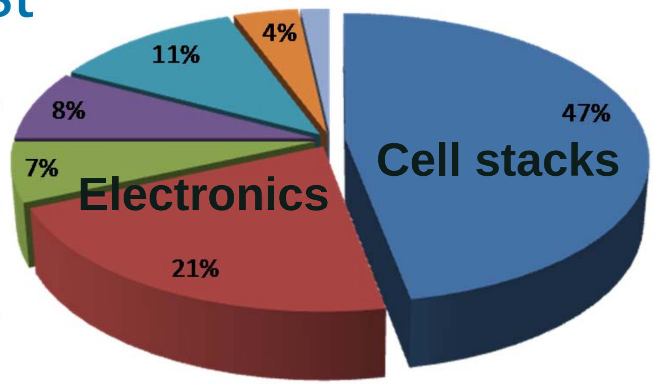
IEA-AFC ANNEX 30 – MEGAPEM Workshop

21 April 2015

Historical Cost Breakdown

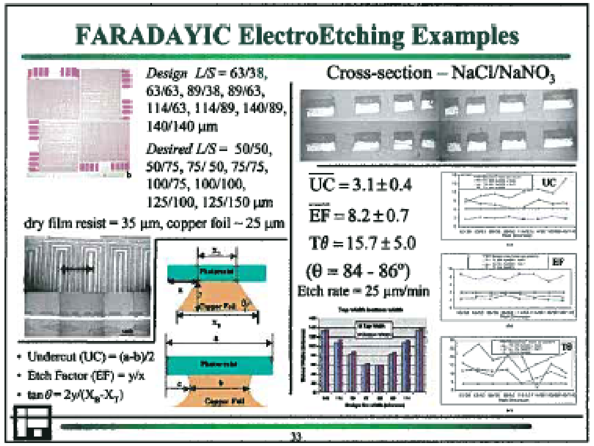
- Flow field, membrane electrode assembly, and labor are high impact cost areas
- Catalyst represents ~6% of total cost





System vs. stack breakdown

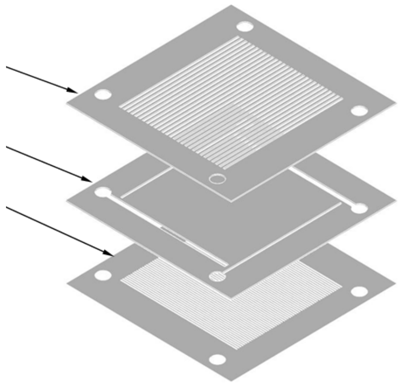
Flow Field Development



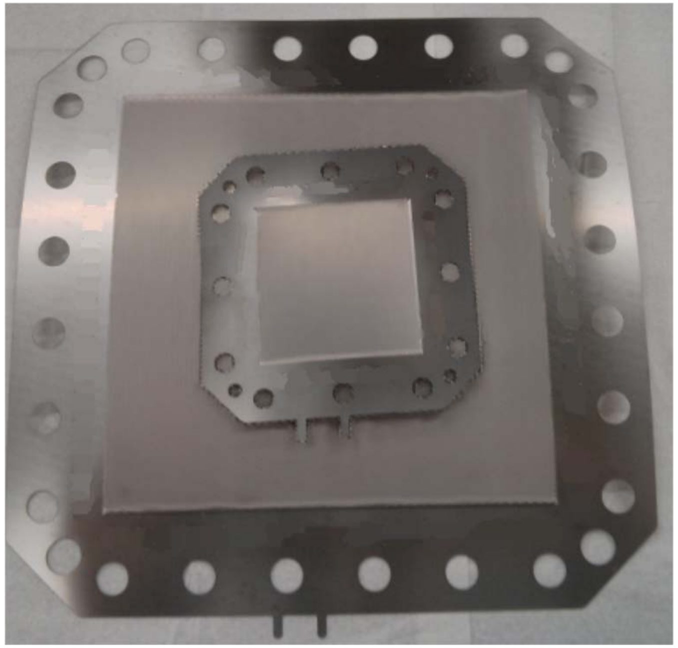
Chemical/Electrochemical Etching

Stamping

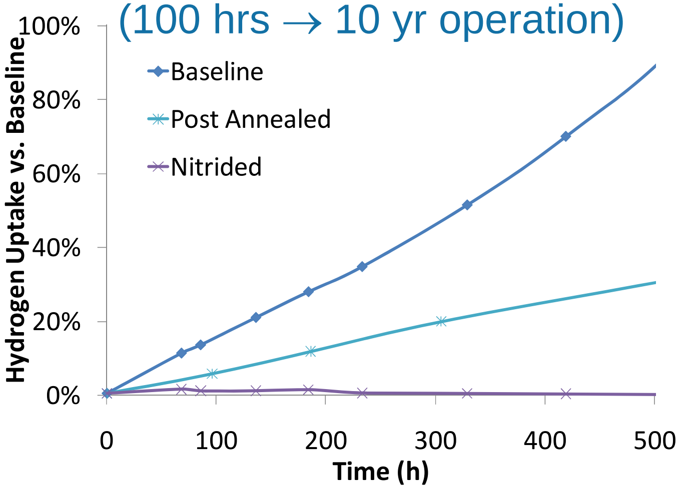
Diffusion bonding



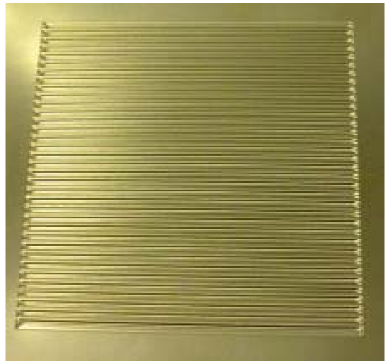
Prototype plates for commercial platform and large active area



Accelerated H_2 Exposure
(100 hrs → 10 yr operation)

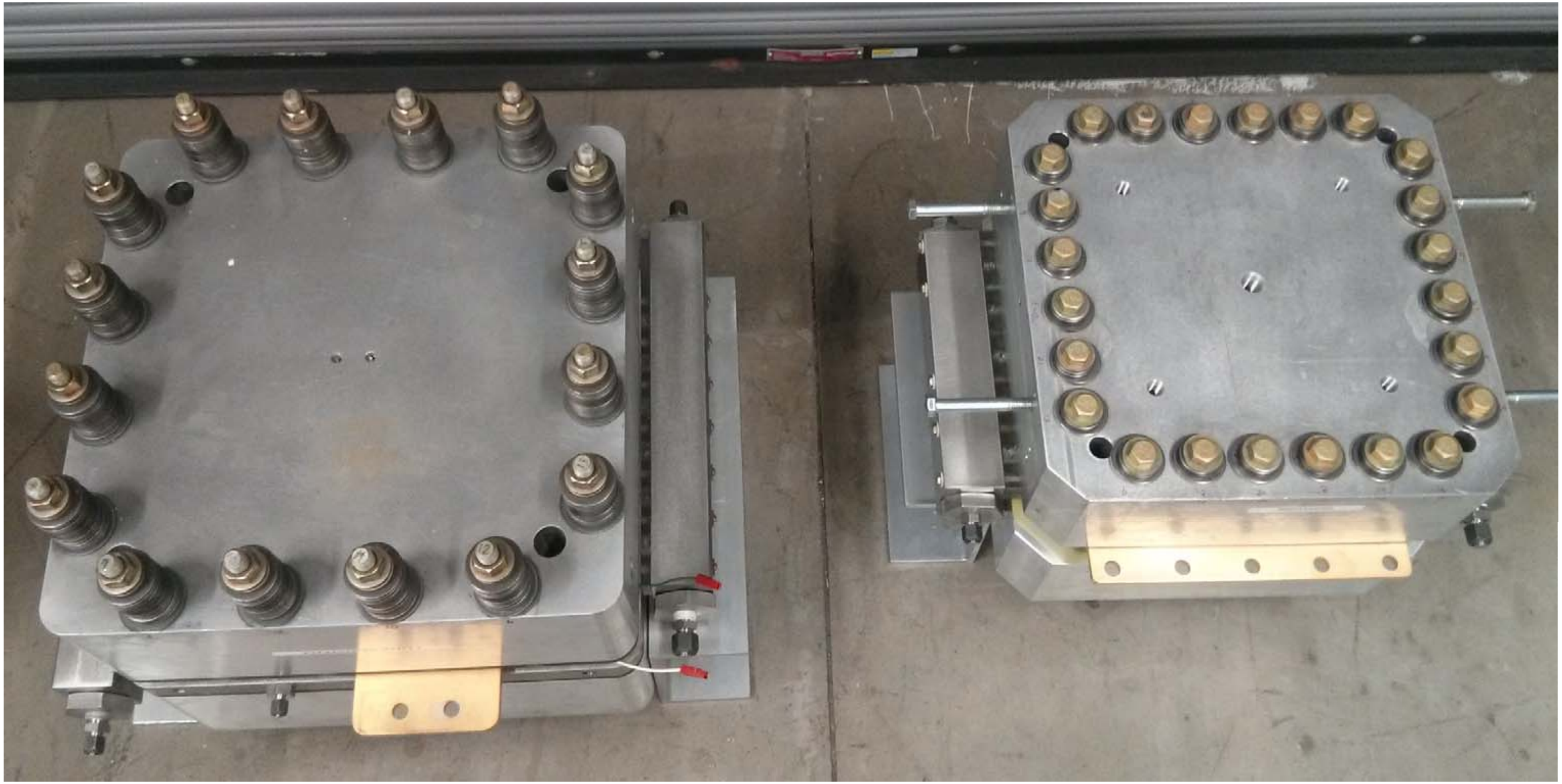


Cross-section of part with coating



Conceptual part made with new manufacturing process/nitride coating

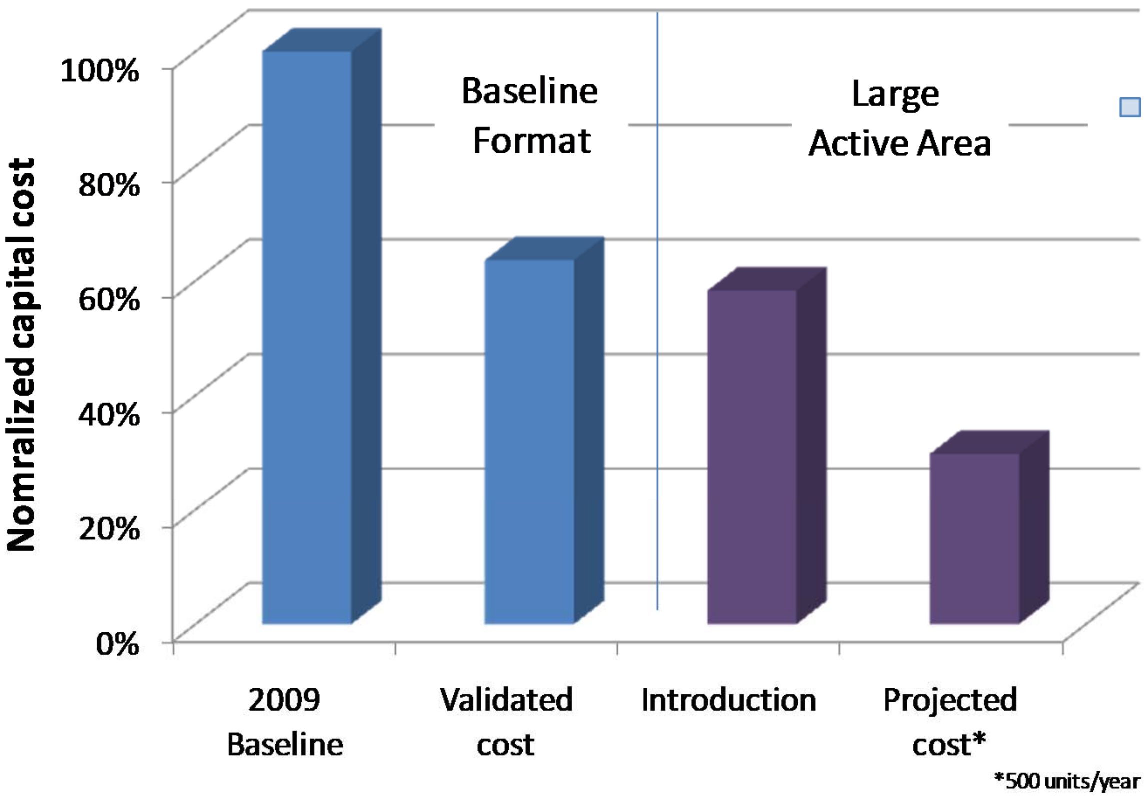
Continuous Design Improvements

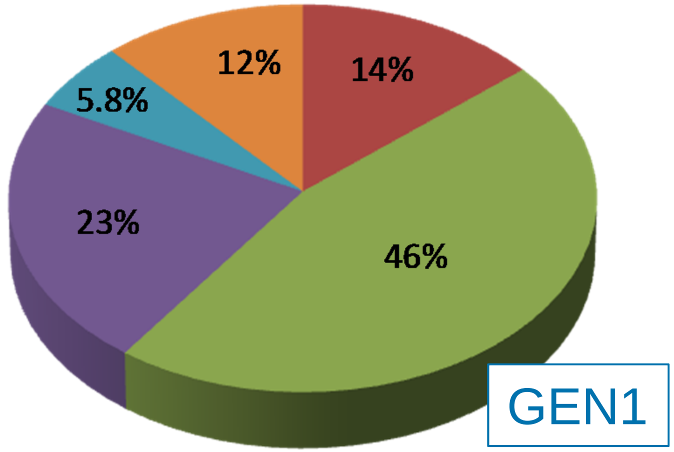


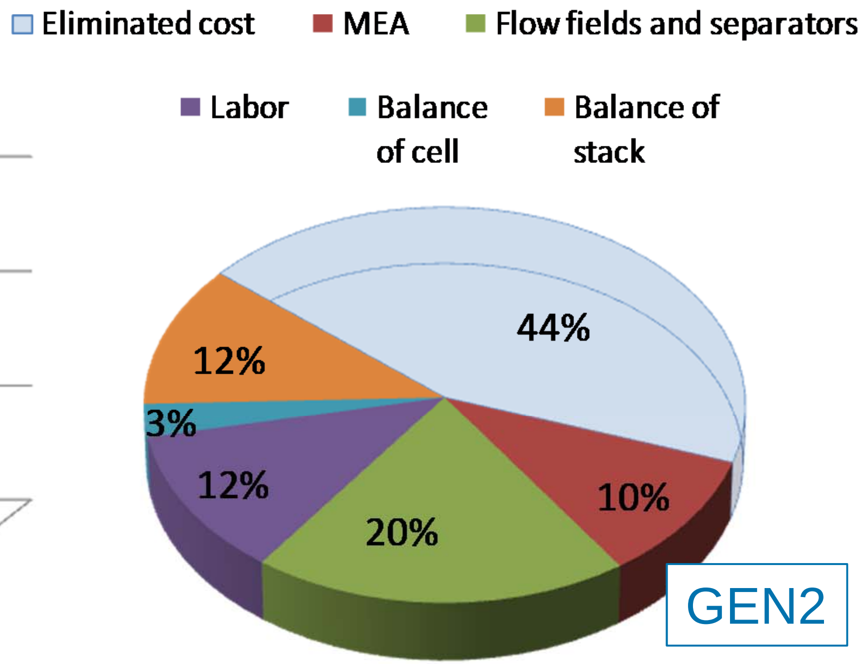
- Stack on the right makes 15% more hydrogen and is 40% less expensive

Improved Cell Stack Design

- 40% reduction in stack cost
- Additional reduction with scale

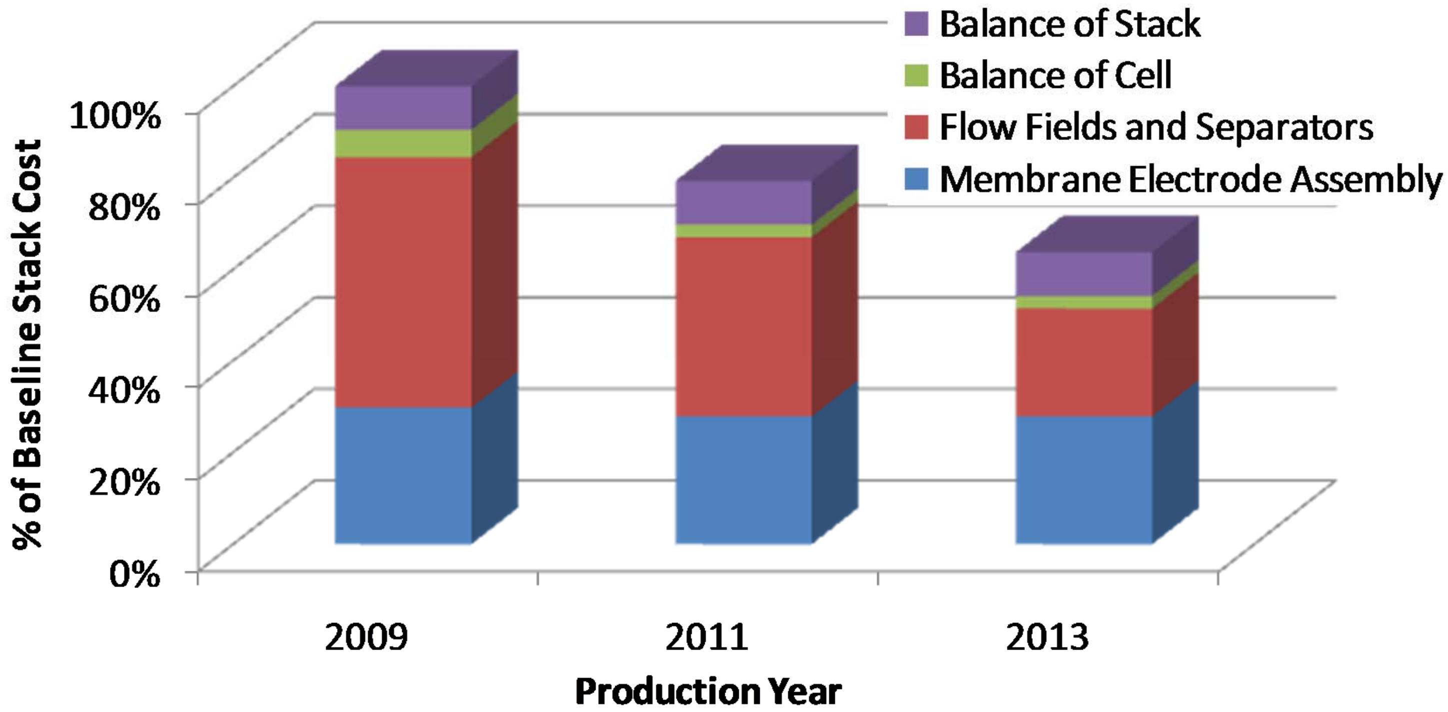






Current Status

- MEA becoming larger fraction of cost
  - PGM content contributes 50% of material cost
  - Also sensitive to PGM price volatility
  - Labor cost in catalyst application also significant
- Higher current density operation largest opportunity for cost reduction

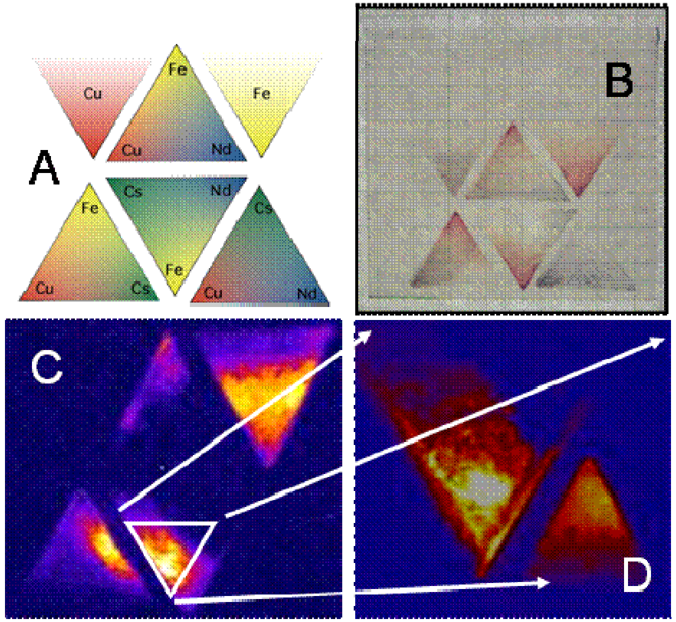


Catalyst Strategies

- Performance:
  - Increase OER activity through composition and process to enhance electronic structure
  - Improve conductivity with improved electrode structure
- Cost:
  - Decrease noble metal content through engineered structures
    - Key challenge for anode is stable non-carbon support
    - Manufacturability is as important as demonstration
  - Decrease labor costs through higher automation and improved quality control methods

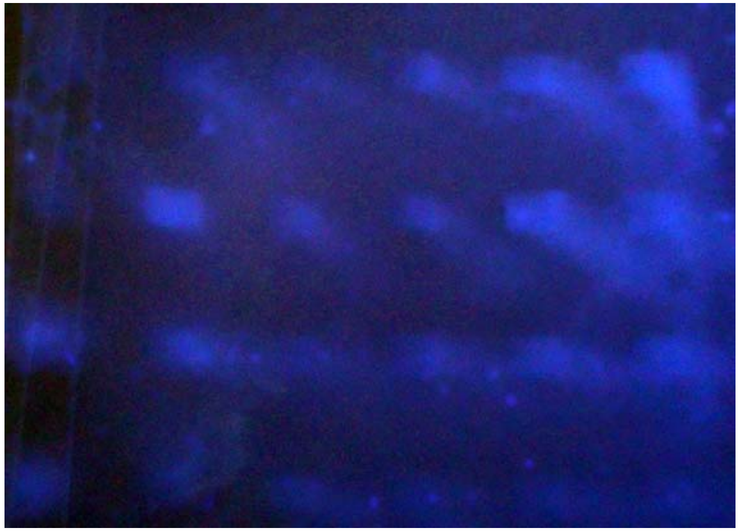
Combinatorial Approach

- Partnership with Parkinson group at U. Wyoming
- Modified measurement technique for electrolysis
- Examined combinations of metals such as Ir, Al, Pt, Ru, Sn, Rh, and Pd



Schematic and results from PEC combinatorial work

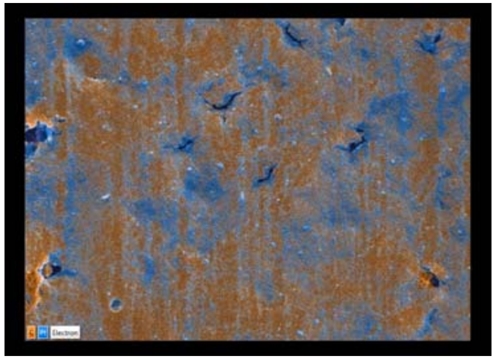
Printer used in electrode fabrication

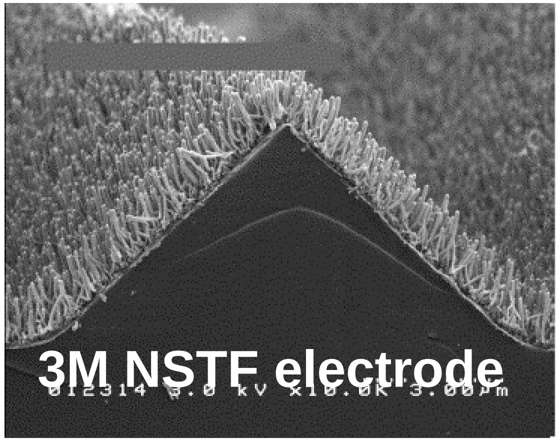


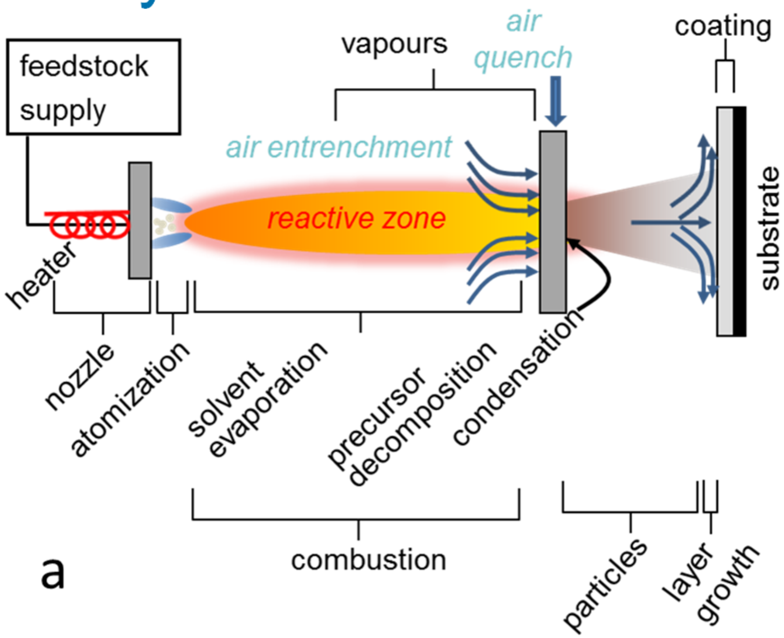
Electrolysis results based on pH fluorescence measurement

Catalyst Approaches

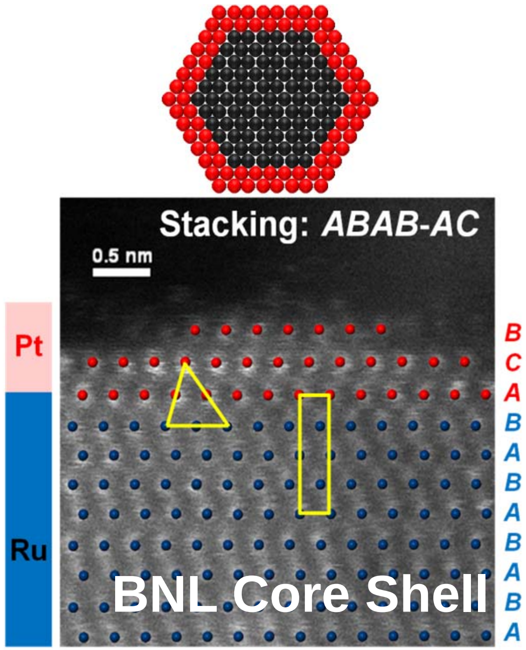
- Several routes showing promise for <10% of current loading
  - Nanostructured thin films
  - Reactive spray deposition
  - Core shell catalysts







UConn RSDT method



BNL Core Shell

Remaining Catalyst Challenges

- Significant focus still needed on the anode
  - Non-carbon supports
  - Re-formulation for spray deposition
  - Refinement of composition
- Durability testing and accelerated protocols
- Manufacturing scale up
- Combination of catalyst advancements with membranes developing in parallel

Membrane Modification Approaches

Approaches to change polymer behavior

- Polymer backbone
- Branching level
- Fluorination vs. hydrocarbons
- Reinforcement
- Blending
- Synthesis method (e.g. electrospinning vs. casting)

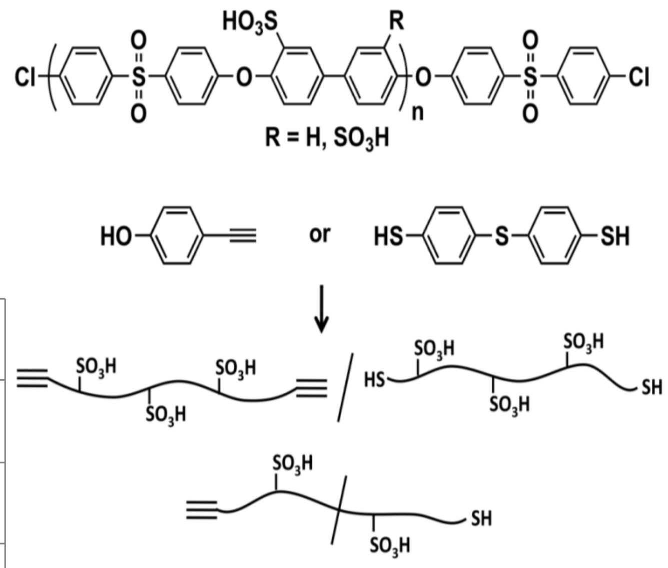
Variables Impacted

- Tensile strength
- IEC
- T_g, creep properties
- Elongation to break (brittleness)
- Conductivity
- Water uptake
- Dimensional change
- F- release rate

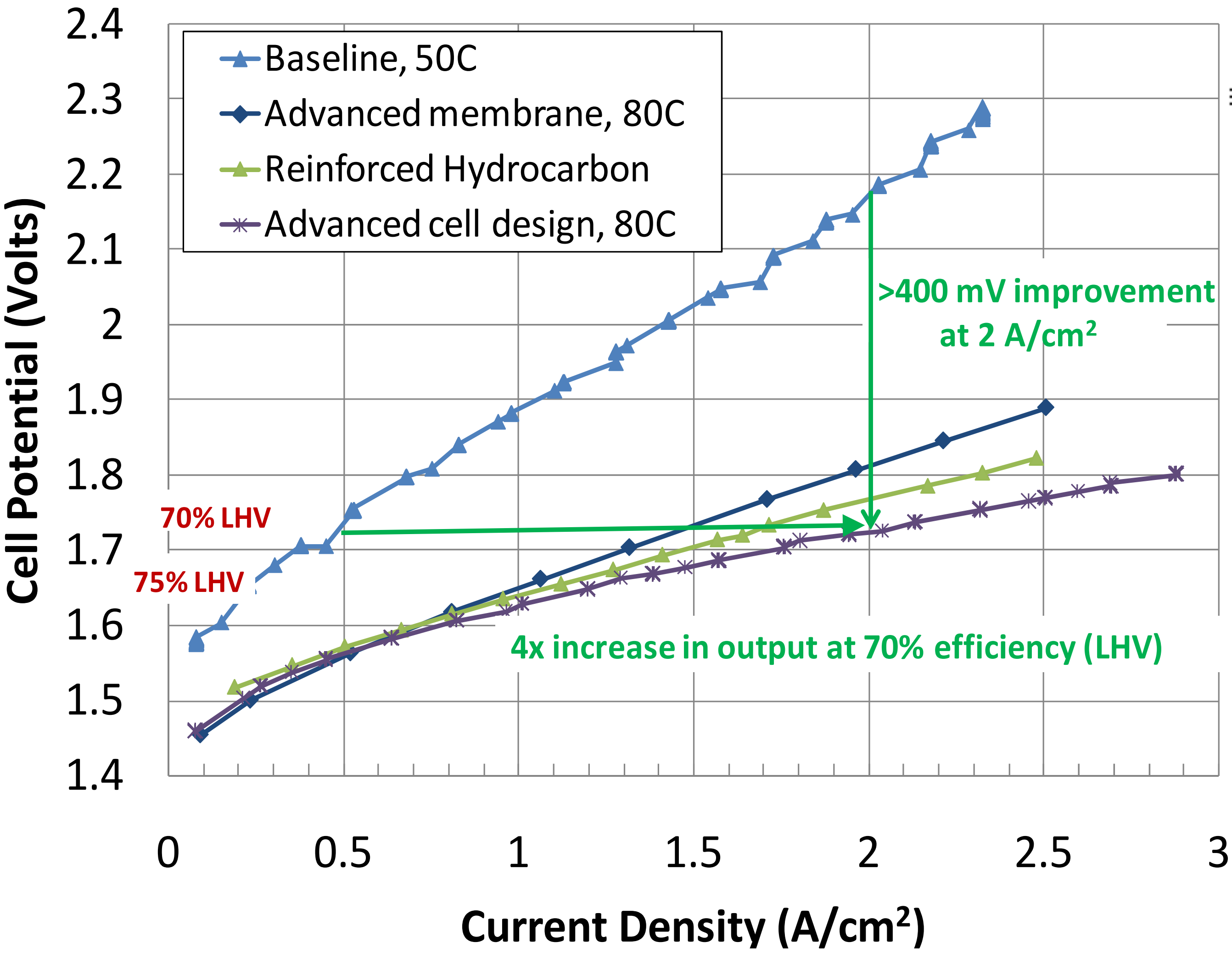
Accelerated testing of new membrane materials would be beneficial in shortening development

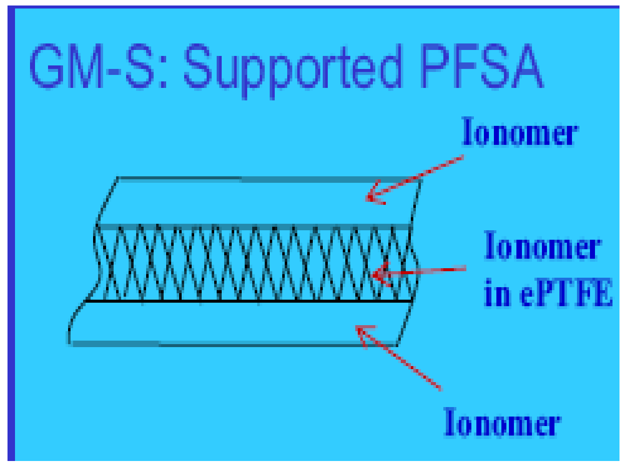
Membrane Advancements

- Some approaches have demonstrated 10,000 hours of durability at 80C



Hickner lab membranes, PSU





PROTON ON SITE

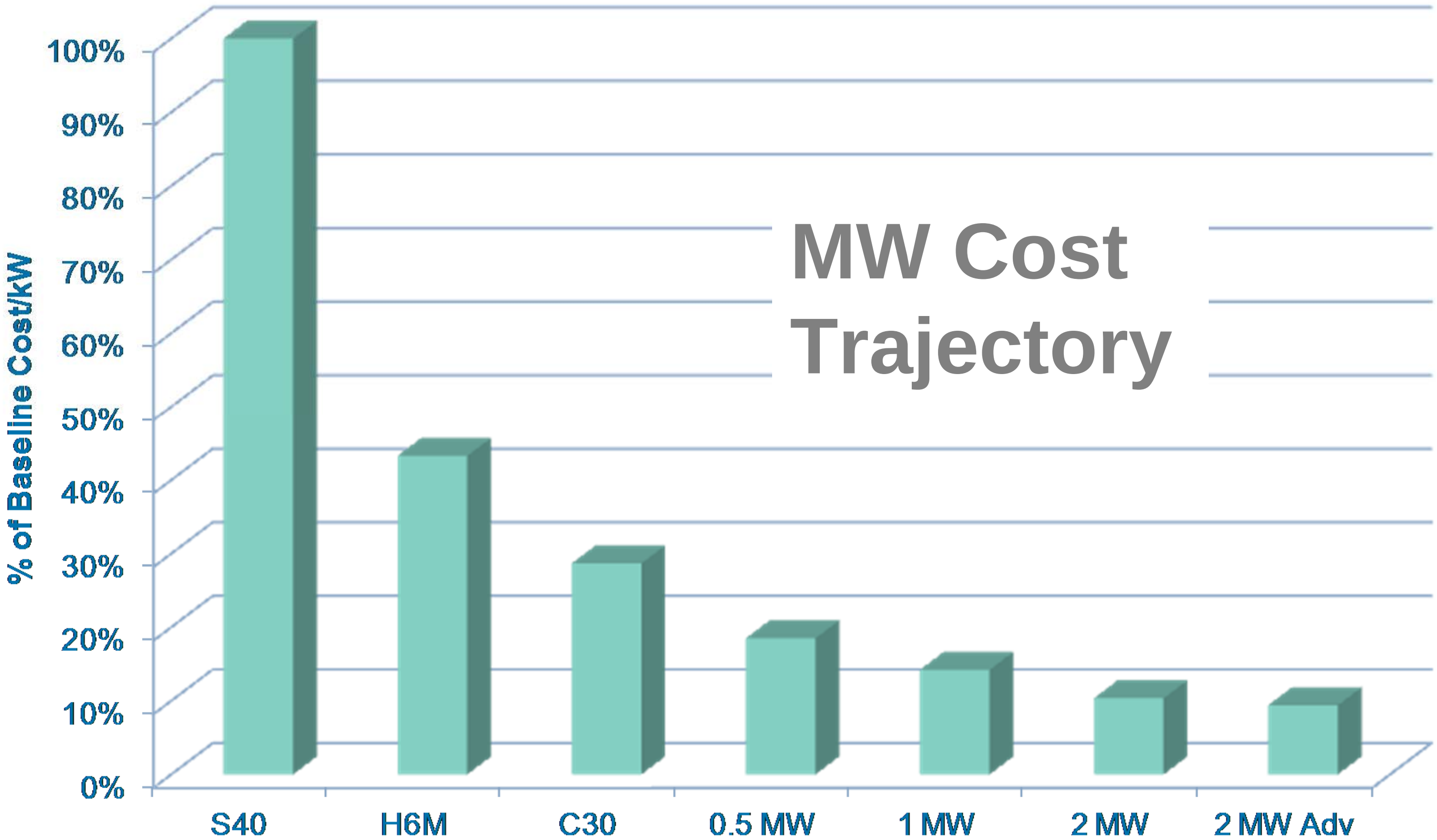
Scale-up/Cost Reduction Experience

	HOGEN S-Series	HOGEN H-Series	HOGEN C-Series
Product Type			
Product Launch	2000	2004	2011
Cells/stack	10-20	34	65
Stacks/system	1	1-3	1-3
H_2 Output (Nm^3/hr)	1.05	6	30
$/kW vs. S-series	100%	43%	28%

Input Power 7kW 40 kW 175 kW

- Order-of-magnitude scale up resulted in greater than 70% cost reduction ($/kW basis)

System Scale-Up Needs



- System cost improves considerably with scale
- Significant technology de-risking already complete
- Engineering scale-up activities remain

Summary and Future Work

- Technology pathways are well-defined and being pursued: short and long term in parallel
- Promising technology already developed beyond feasibility stage
- Strong collaborations with industry, labs, and universities
- Significant potential exists for continuing cost and efficiency improvements in PEM electrolysis