DOE Hydrogen Program

Low-Cost Manufacturable Microchannel Systems for Passive PEM Water Management

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FCP20

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Overview

Timeline

- Start – February, 2007
- End – September, 2008
- 15% Complete

Budget

- $1000K Total funding
  - DOE share – 100%
  - Contractor share – 0%
- $300K FY07 funding

Collaborations

- PNNL – PM & technology development
- ADMA – Manufacturing Support
- Protonex – Fabrication methods
- Hydrogenics – Testing Support

Barriers

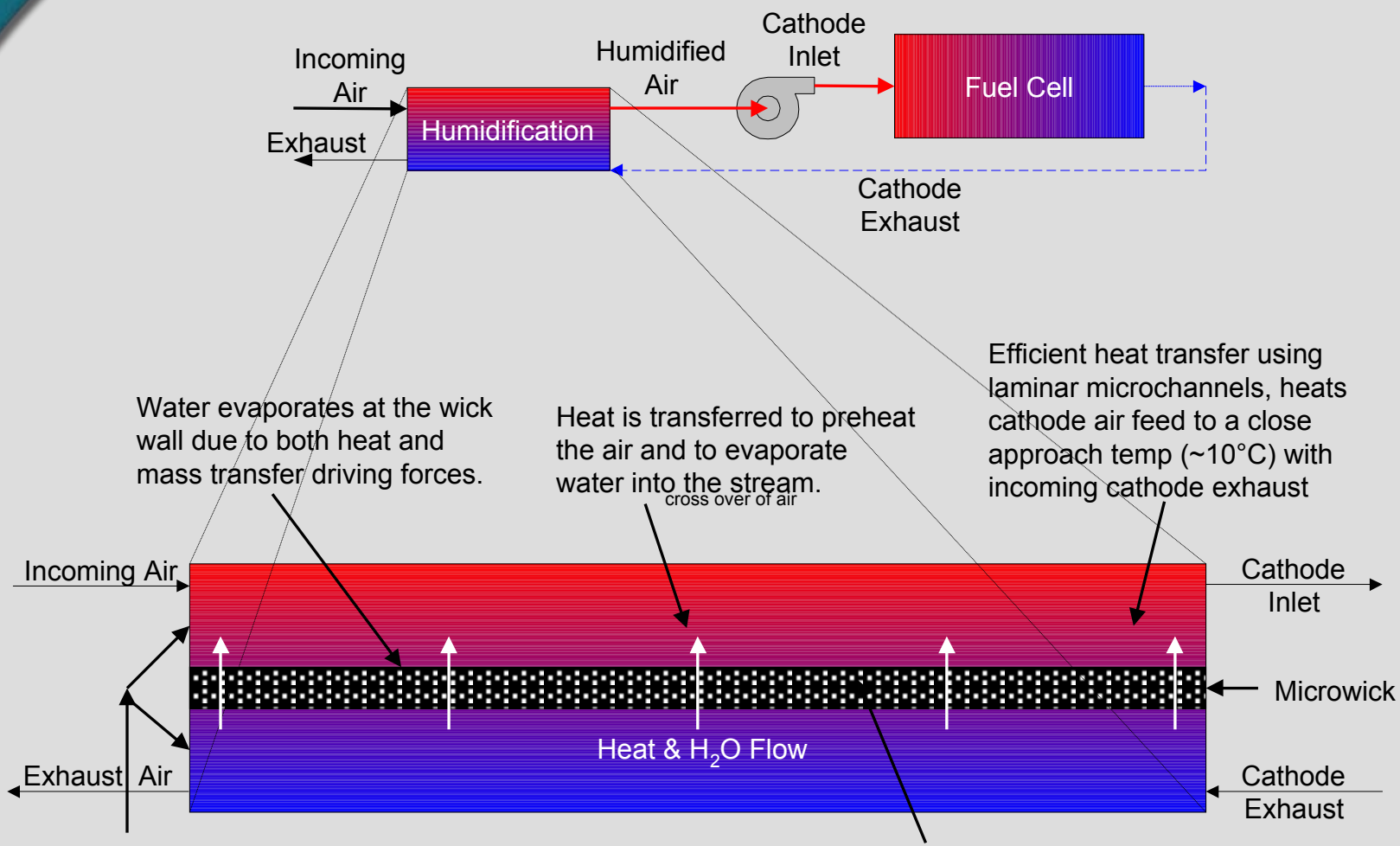
- 3.4 Fuel Cells Barriers
  - B. Cost:
  - E. System Thermal and Water Management
- Targets
  - 3.4.2 Automotive-Scale: 80 kW_e Integrated Transportation Fuel Cell Power Systems Operating on Direct Hydrogen

	Target	80 kW_e System	Water Mgmt Target %
Power Density	650 W_e/L	123 L	2–7%
Specific Power	650 W_e/kg	123 kg	2 - 9%
Cost	$30/$kW_e$	$2400	< 7%

Objectives

- **OVERALL**
  - Create a low cost, passive technology for water management in PEM systems
- **FY07**
  - Complete single channel testing
  - Initiate 1 kW_e-scale device design and fabrication
- **FY08**
  - Complete 1 kW_e-scale testing
  - Demonstrate 10 kW_e-scale device in PEM system
  - Validate low cost manufacturing process

Approach


Incoming Air
Exhaust
Humidification
Humidified Air
Cathode Inlet
Fuel Cell
Cathode Exhaust
Water evaporates at the wick wall due to both heat and mass transfer driving forces.
Heat is transferred to preheat the air and to evaporate water into the stream.
cross over of air
Efficient heat transfer using laminar microchannels, heats cathode air feed to a close approach temp (~10°C) with incoming cathode exhaust
Incoming Air
Cathode Inlet
Microwick
Heat & H_2O Flow
Exhaust Air
Cathode Exhaust
Interconnect wicks are built into headers to remove excess water during normal operation and supply water during start up.
Capillary forces convey water condensed from the humid exhaust to the dry incoming air and also prevent cross over of air by precluding air intrusion into the wick.

Technical Accomplishments/ Progress/Results

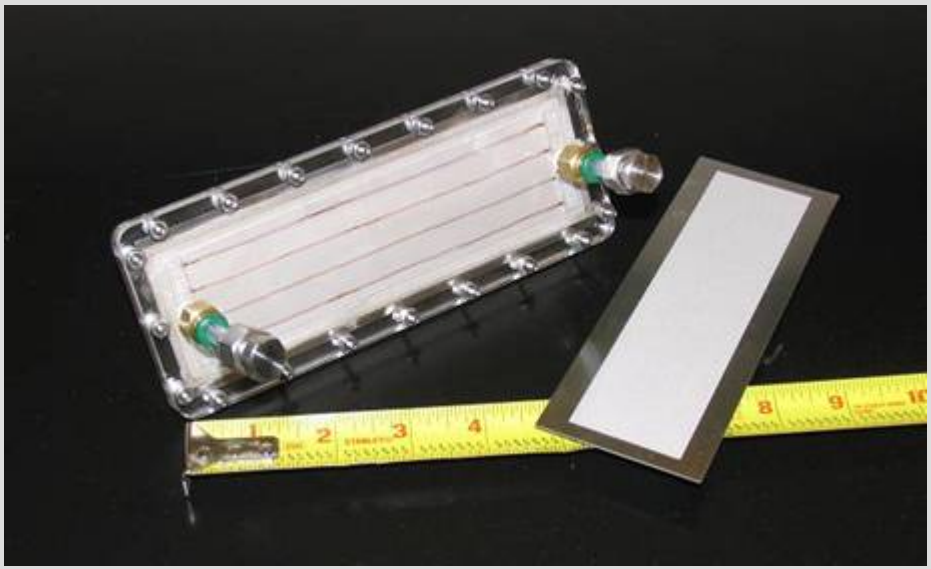
- **System Performance Requirements**
  - **Heat transfer and water recovery at varying fuel cell and ambient temperatures**

Fuel cell temp	Ambient Temp	Hot End Approach Temp	Cold End Approach Temp	Excess condensate
80 °C	25 °C	12 °C	37 °C	1.6%
80 °C	40 °C	5 °C	34 °C	1.6%
60 °C	25 °C	12 °C	32 °C	34%
60 °C	40 °C	11 °C	27 °C	34%
90 °C	40 °C	2 °C	21 °C	0.3%

  - **Water balance is possible up to 90°C FC temp and 40°C ambient**
  - **Approach temp becomes very challenging at highest temperatures**

Accomplishments/Progress/Results Slides

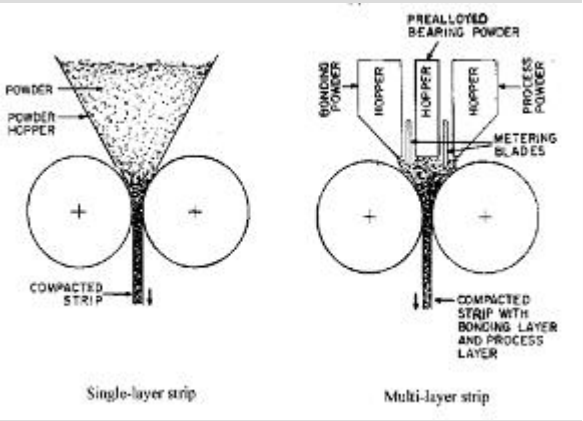
- **Task – Single Channel Demonstration and Testing**
  - **Single channel device constructed**

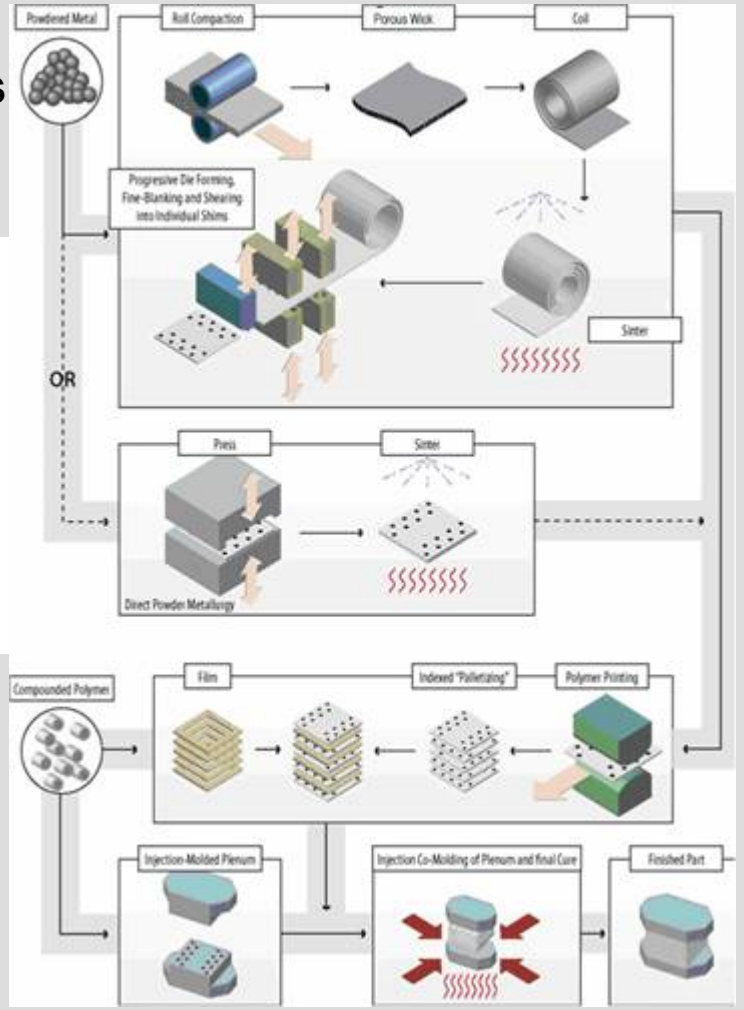


  - **Test system operational**
  - **Single channel testing initiated**

Accomplishments/Progress/Results Slides

- **Task –Manufacture of Components**
  - Initial focus on porous materials for wicks
  - Direct powder rolling with ADMA

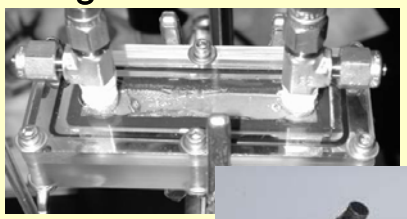




  - 0.005 to 0.030 inch thicknesses
  - Layered structures possible

Relevant Prior Work: Microwick Technologies

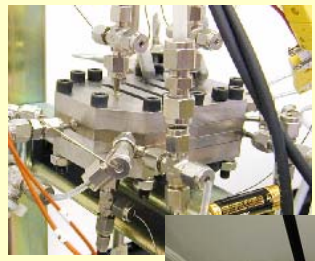
Single channel



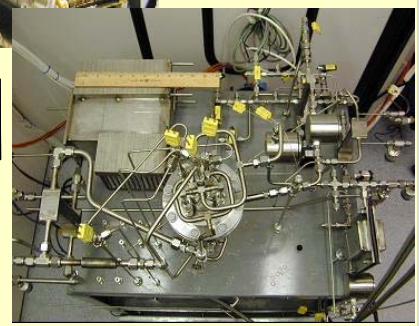
Phase separation

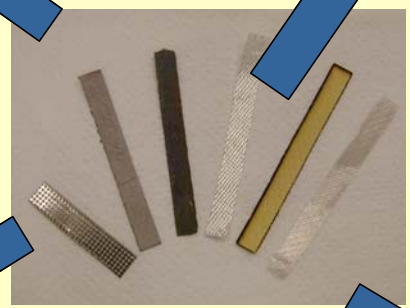
Multichannel

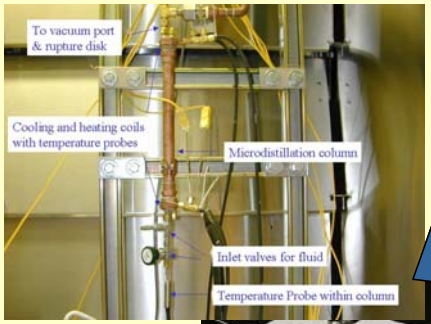
Absorption & Desorption



Integrated heat pump

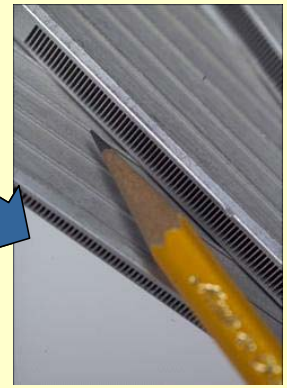






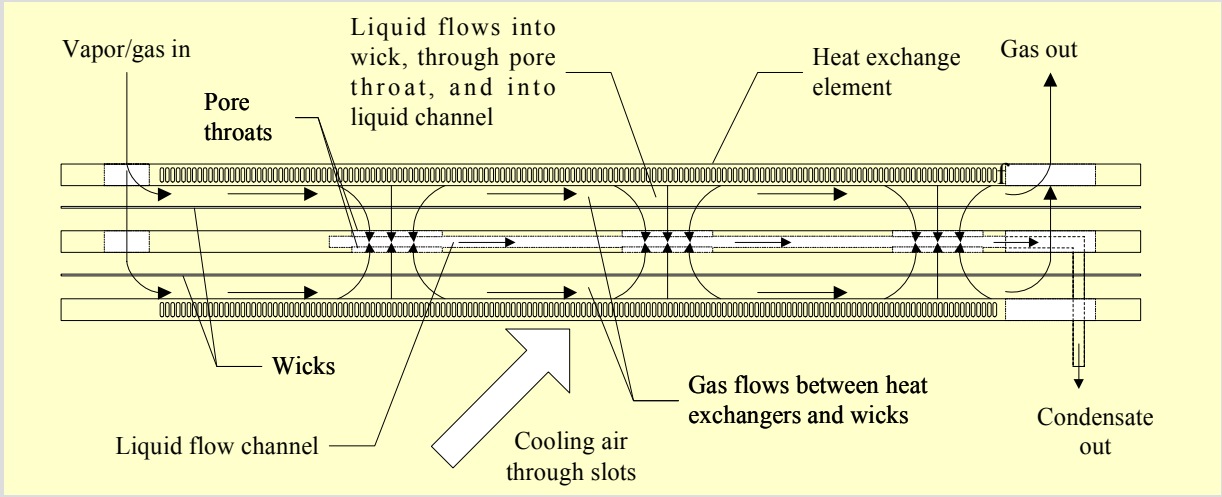
Distillation

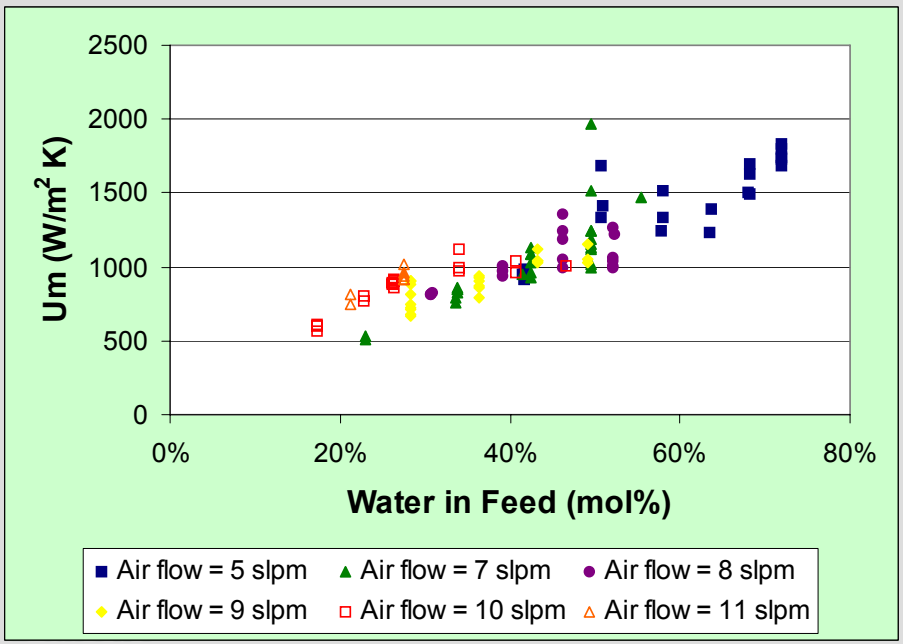
Microwicks allow two phase flow

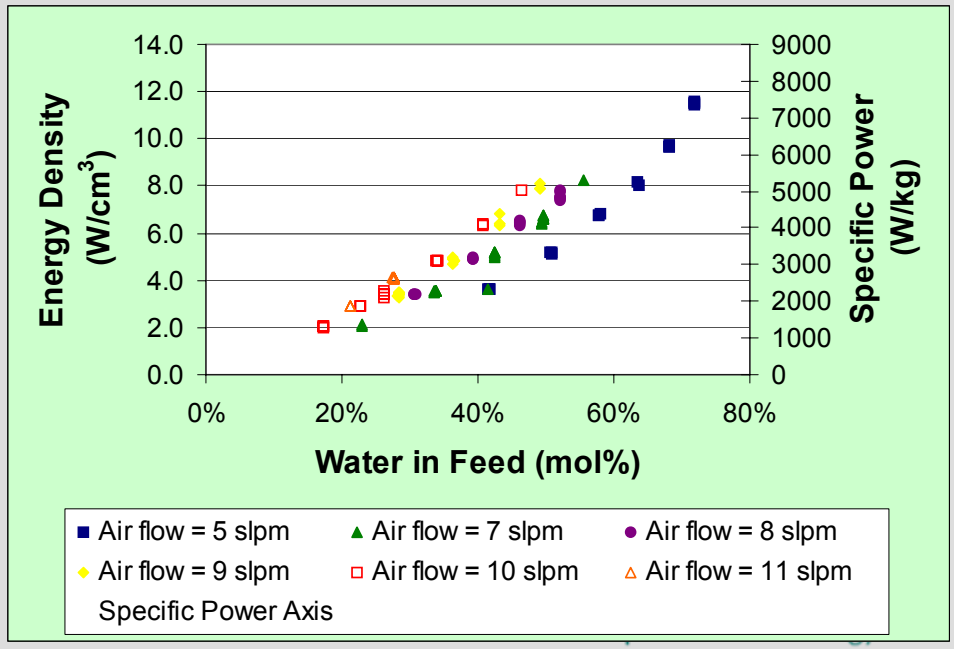


Phase separation with partial condensation

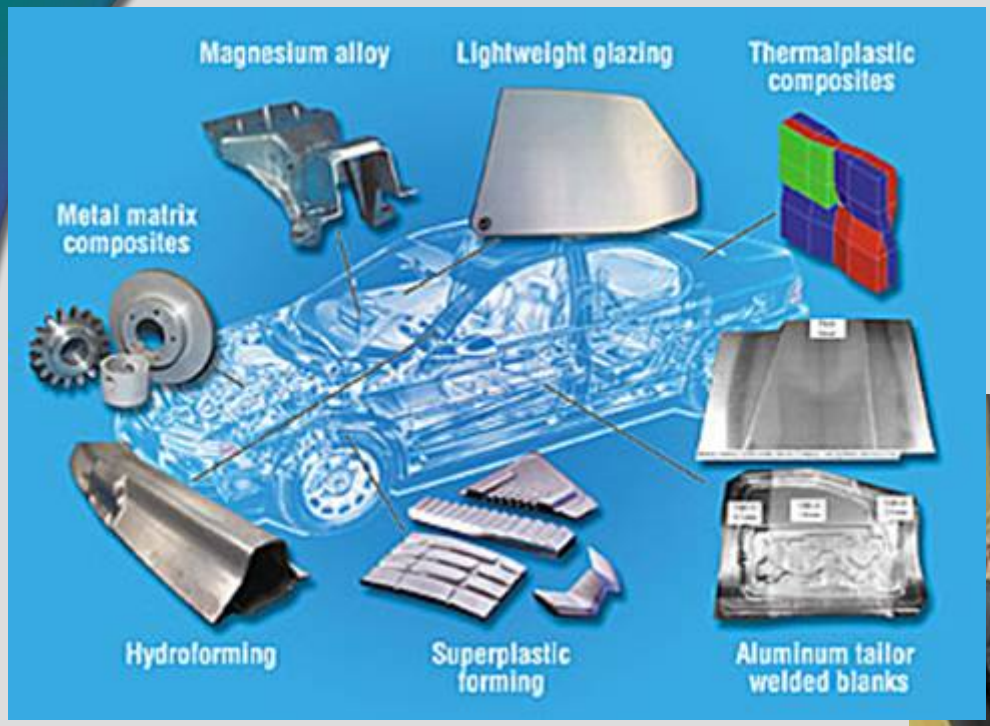
Performance for Phase Separation with Partial Condensation







Relevant Prior Work in Manufacturing



Novel automotive components and processes
for high volume production

PACCAR Hybrid Door

Superplastic aluminum Malibu Maxx lift gift

Future Work

- **FY07**
  - Complete single channel demonstration and testing
  - Initiate 1 kW_e-scale device design and fabrication
    - Construct design tool for wicking humidifiers
    - Validate design tool with single channel data
- **FY08**
  - Complete 1 kW_e device fabrication and testing
  - Scale-up to 10 kW_e-scale device
  - Demonstrate 10kW_e-scaled device in fuel cell system
  - Validate low cost manufacturing process
- **Key Go/No Go Decision – end of Phase 1**
  - Ability of device to meet weight and size targets
  - Ability of device to handle varying conditions
  - Costs for manufacturing 80-kW_e device at <$100

Summary

- Balance of plant components, specifically for heat exchange and humidification, require additional development to meet requirements
- Microwick approach offers advantages for PEM Fuel Cell systems
  - Small size due to high power density heat transfer and rapid mass transfer
  - Passive operation
  - Low pressure drop enabling operation with blowers
  - Orientation independent
  - Self recovery during process upsets
- Device architecture is amenable to low cost, high volume manufacturing