Fuel Cells in Military Applications

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Purpose

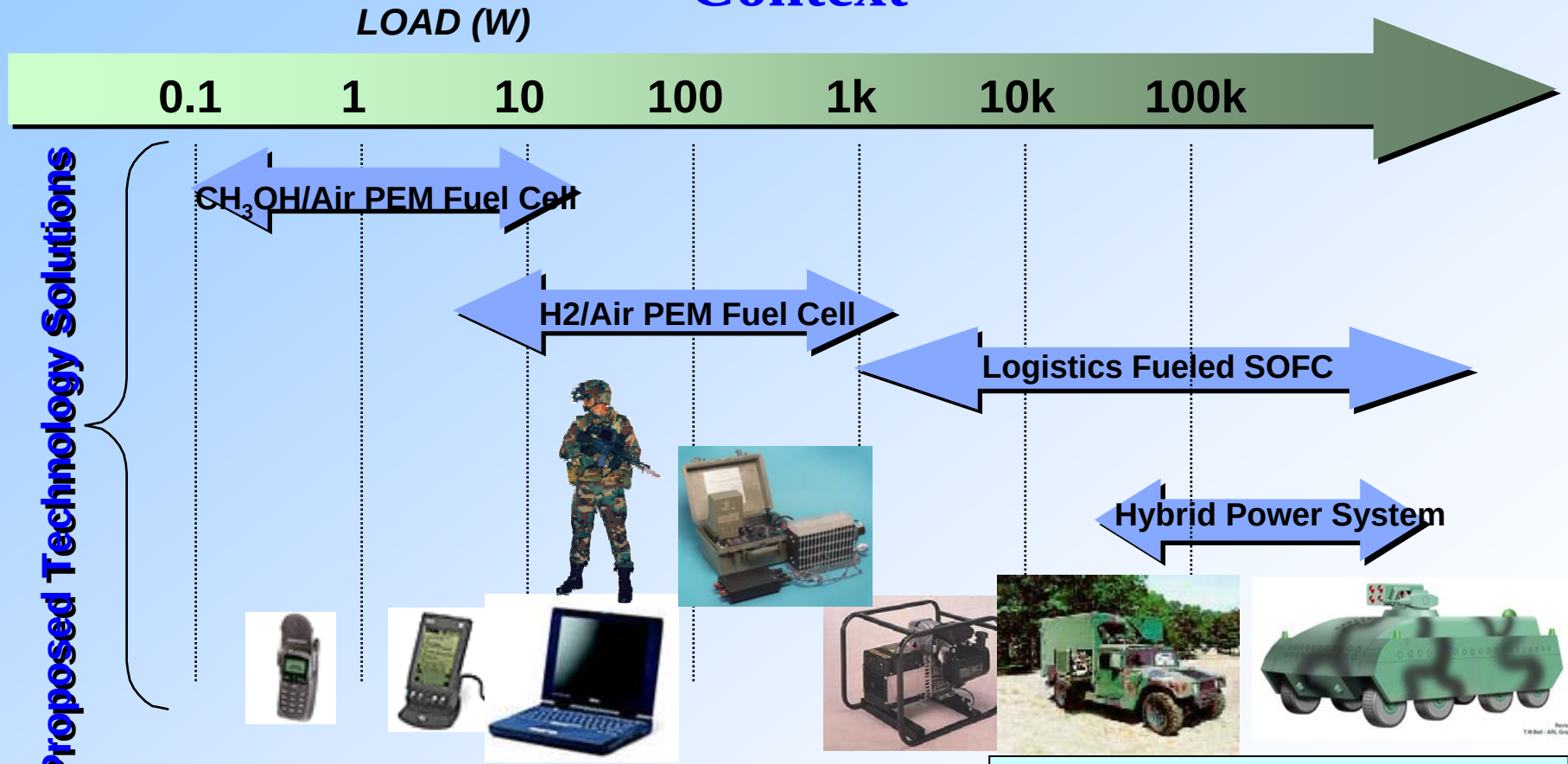
- To provide an overview of my experience at ARL and describe the application of skills gained from learning and working with professional engineers in the civilian environment.

Agenda

- Background on ARL Fuel Cell and Fuel Reformation Programs
- Problem Statement
- How Fuel Cells Work
- Building Fuel Cells
- Fuel Cell Configurations
- Further Research Opportunities
- 41st Power Sources Conference
- Questions

Army Research Laboratory Fuel Cell and Fuel Reformation Programs

Context



Direct Methanol Fuel Cells (DMFC)

Reformed Methanol to Hydrogen Fuel Cell (RHFC)

Solid Oxide Fuel Cell (SOFC) and Reformation

- Decreased fuel consumption and logistic burden
- Smaller sizes
- Increased range
- Increased power availability

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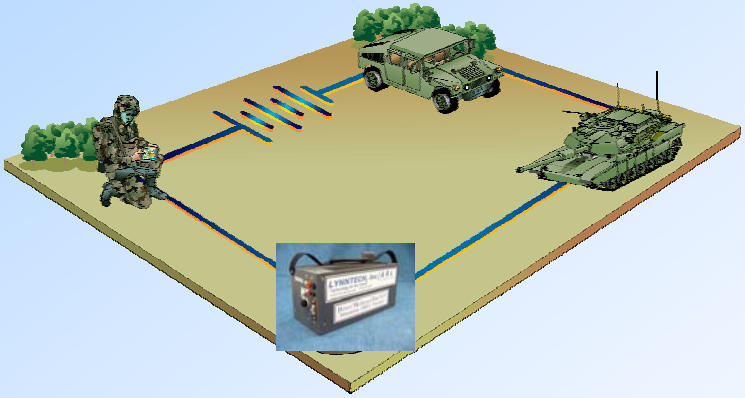
Fuel Cell and Fuel Reformation Programs

Materials and technology for fuel cell systems

- Focus on low / medium power (20W to 5 kW)
  - OFW: 20-300W direct/recharge
  - FCS: 1-5 kW APUs (silent watch, APU, robots)
- More efficient elctrocatalysts and protonic membranes for direct utilization of fuels
- Hydrogen generators/fuel reformers for hydrogen-fueled cells
- Solid oxide fuel cells for direct and indirect utilization of hydrocarbon fuels



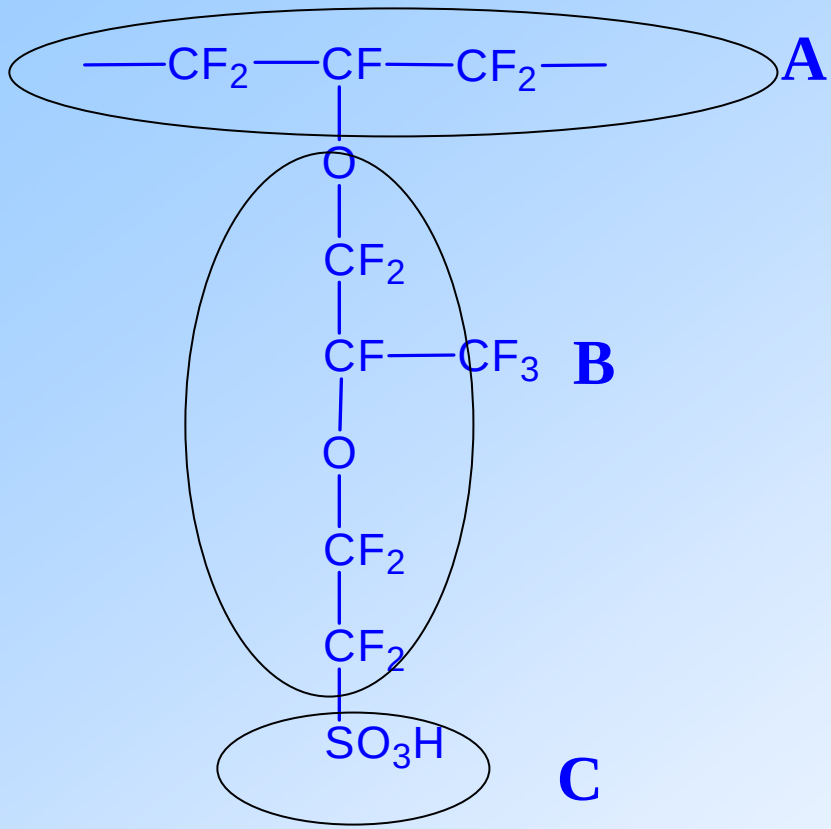
- *Fuel cells for battery chargers*
- *Direct power for Soldier systems*
- *Direct and auxiliary power for FCS vehicles and platforms*

Problem Statement

- Gain an understanding of fuel cells in order to provide a knowledge base for further research in the field.

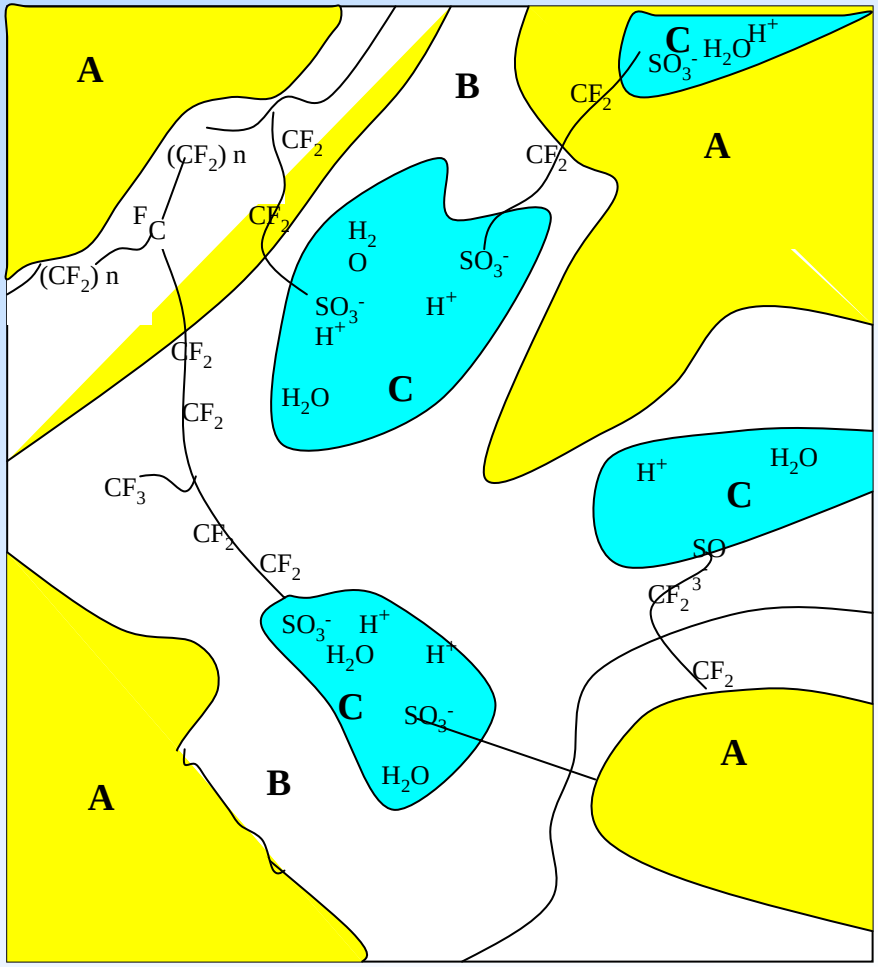
Proton Exchange Membrane -Nafion

Chemical Structure of Nafion



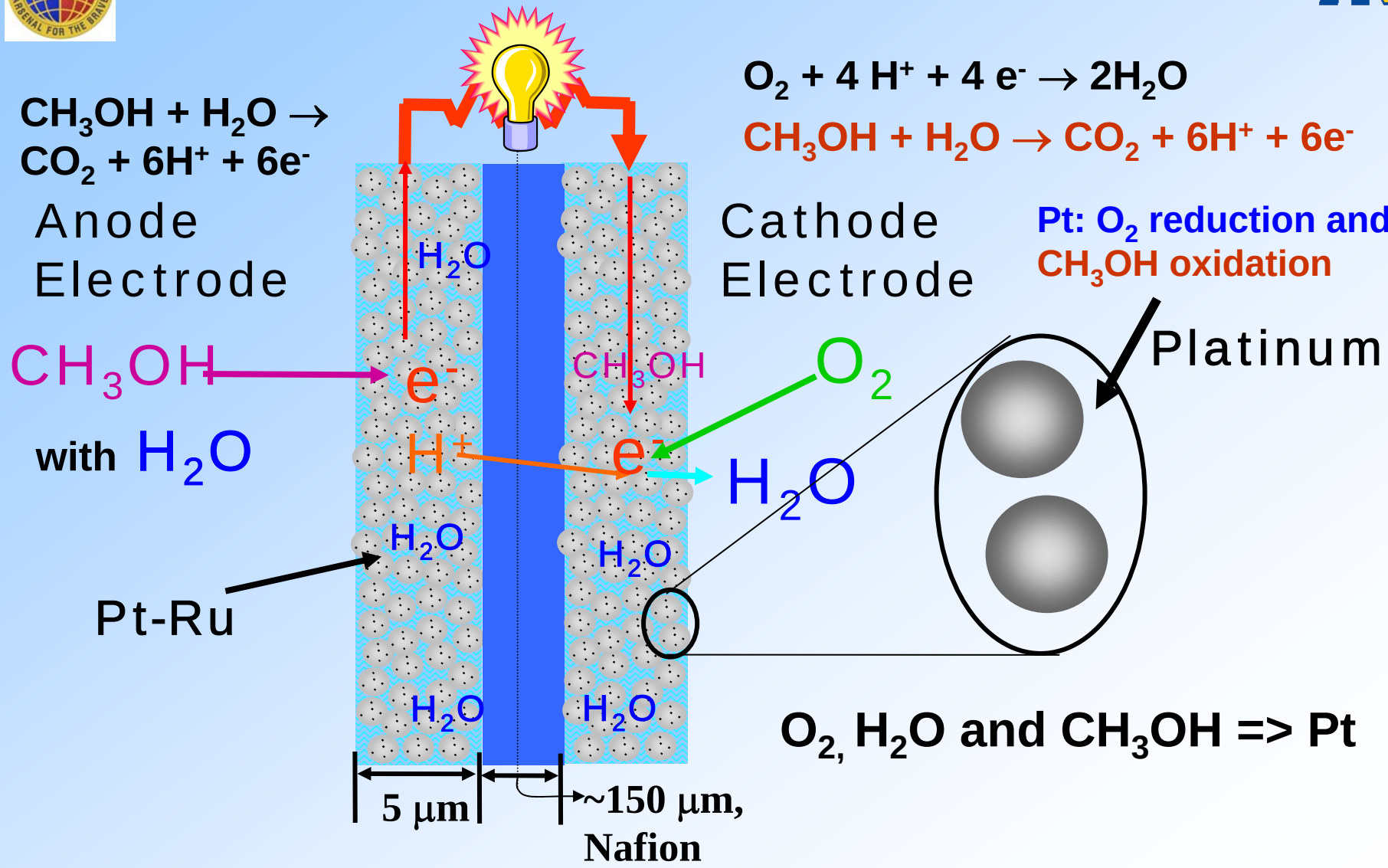
Poly(perfluorosulfonic acid) - Nafion

Physical Structure of Nafion



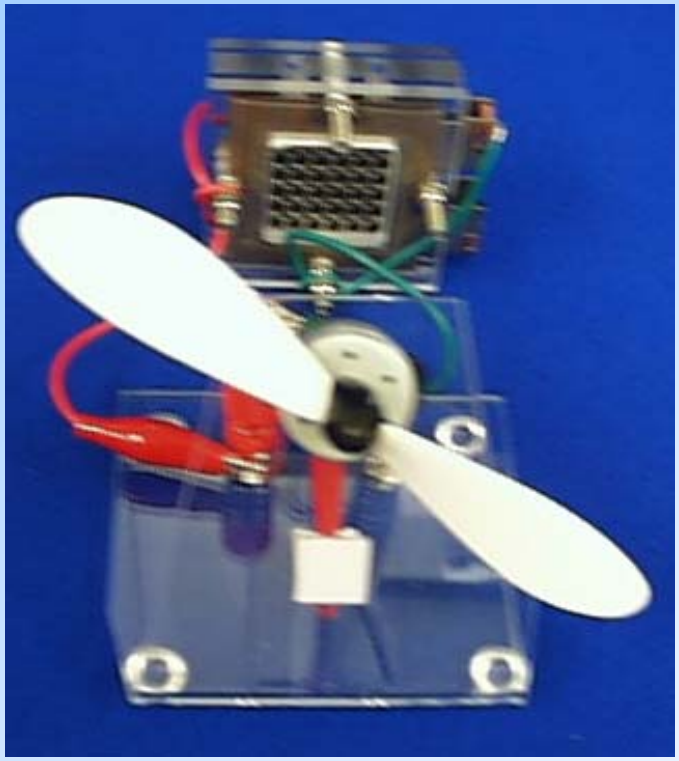
Three region structure model for Nafion: A: fluorocarbon, B. interfacial one and C. ionic cluster

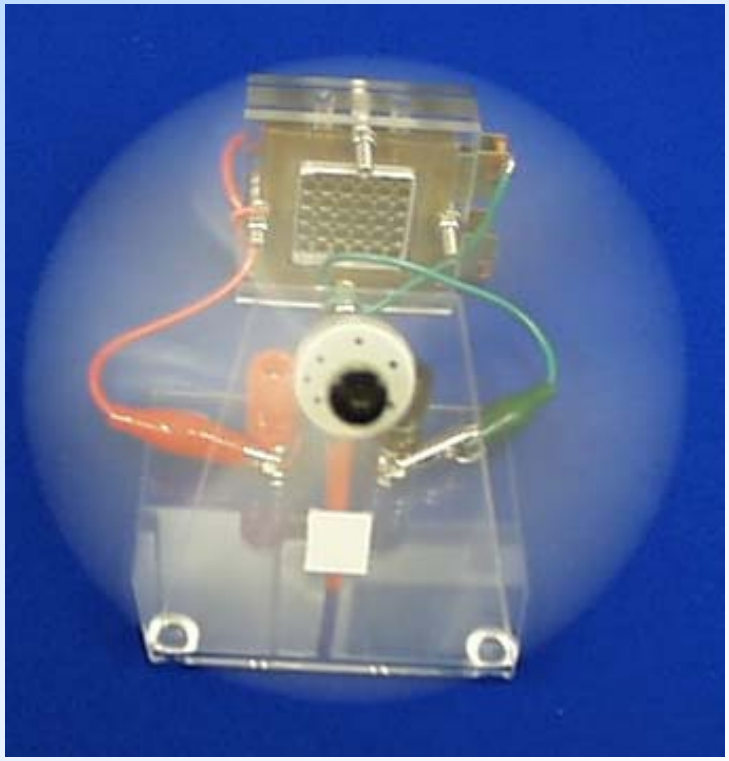
DMFC Membrane Electrode Assembly



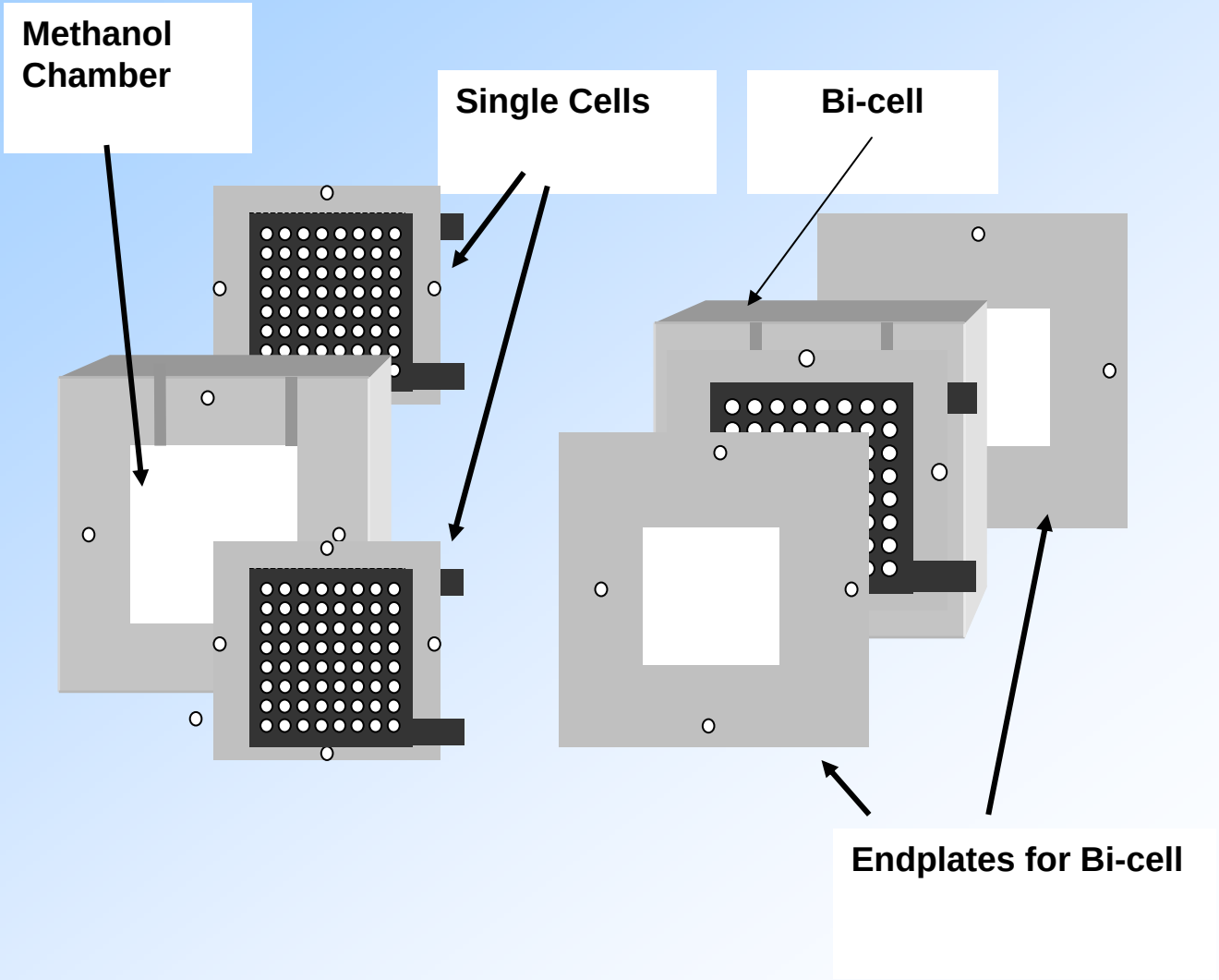
Building Fuel Cells

An Air-breathing DMFC Bi-cell Powering A Small Fan

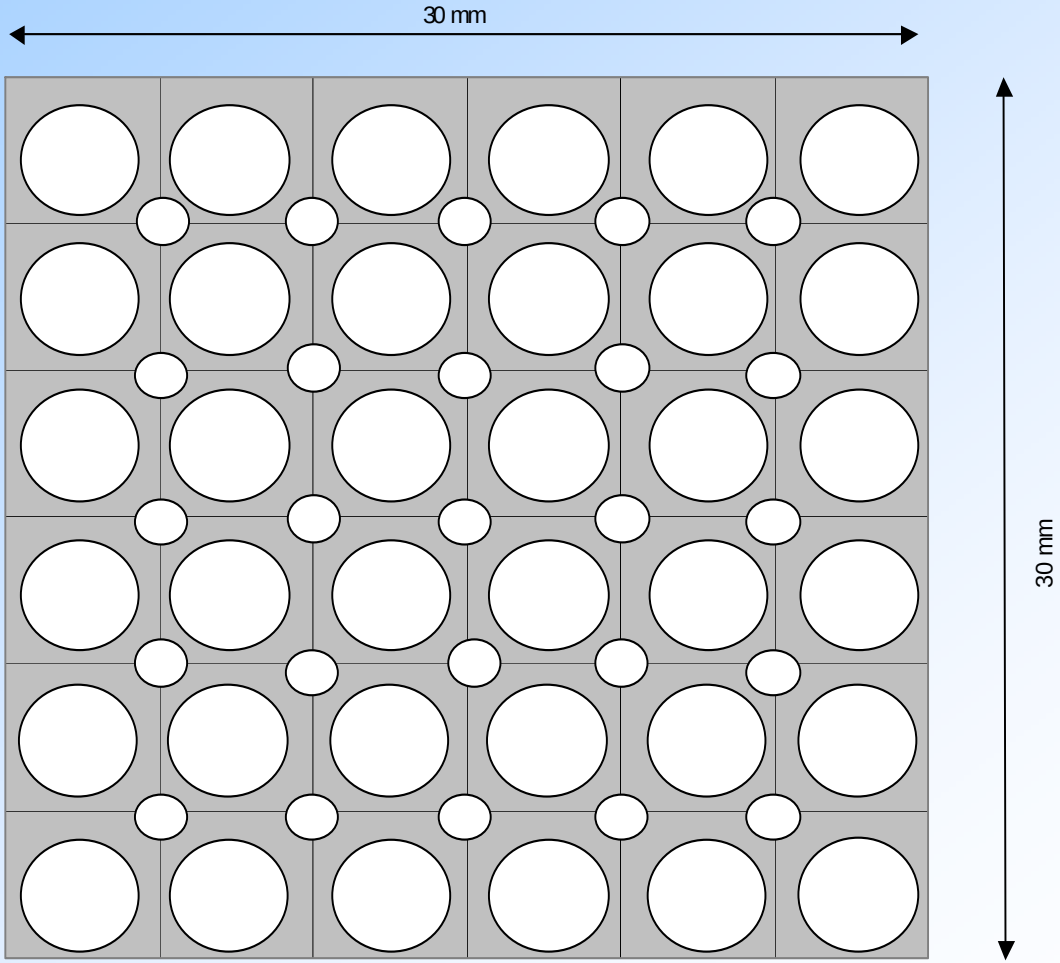




Bi-Cell Configuration



Pore Size Design of Current Collector for Gas and Fuel Transport



Stack Designs

Characteristics of Three Different PEMFC Designs

type	Advantages	Disadvantages
Bipolar PEMFC	• Each electrode plate serves as anode and cathode in the stack • Compact volume • Low internal resistance • Able to operate at high pressure • Easy to achieve high power design • Rugged	• Requires heat management • Requires water management • More expensive of bipolar plates in material and processing • Compressed air is required for oxidant
Pseudo-bipolar (bi-cell) PEMFC	• Moderate internal resistance • Easy to assemble high voltage stack with more bi-cell units • Heat management is easy to be achieved with an auxiliary fan • Oxidant (air) can be provide d by environment with an auxiliary fan • Portable of system design	• Requires humidity management required • Need to fill fuel to each bi-cell unit separately • Need to link each bi-cell unit electronically
Mono-polar (strip) PEMFC	• Anode and cathode can be arranged on the same electrode plane plate • Light weight • High voltage • Has greatest power density by weight • Oxidant (air) can be provide d by environment with or without an auxiliary fan	• High internal resistance • Unable to obtain large cell number on the same strip plain plate because of high resistance • Unable to achieve high power stack system • Fragile

Research Opportunites

- Improving efficiency of fuel cell systems.
- Provided an excellent base for further research, possibly as a capstone project.
- Experiencing the facilities of ARL was very educational.

41st Power Sources Conference

- Saw the applications of various forms of alternate power sources.
- Had the opportunity to interact with civilian and military personnel in the field of energy conversion systems.
- Learned about the cutting-edge technology used in these alternate forms of energy.
- Enabled me to see future energy sources on a wider scope.

Acknowledgements

Questions?