

*Queen's-RMC*  
*Fuel Cell Research Centre*

# Overview of Current Research Activities

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# *Fuel Cell Research Centre*

## Overview of Current Research

### Areas of Research

PEM Fuel  
Cells

Solid Oxide Fuel Cells

Fuel  
Processing

Hydrogen Production  
and Storage

### Areas of Core Expertise

Reliability and Durability Testing

Polymer Composite  
Manufacturing Methods

Mathematical Modelling

Manufacturing Cost Modelling

Ceramics and Nanomaterials

Catalysis and Reaction Engineering

Process Development (Computational  
Thermodynamics)

# Reliability and Durability Testing

- PEMFC Flow-Field Plate Material Testing (Karan-Queen's/Peppley-RMC/DuPont)
  - two automated fuel cell test stations
  - pressure cycling test, accelerated aging test, gas permeation test, contaminant release test, physical properties
- MEA Durability Testing (Fowler-Waterloo)
  - long-term MEA performance test station
  - MEA failure forensic methods

# Polymer Composite Manufacturing Methods

- Conductive Polymer Composite Joining Technologies  
(Bates-RMC/DuPont)
  - novel methods for fabricating flow-field plates
  - 2 patents filed
  - adding functionality to the flow-field plate product

# Mathematical Modelling

- SOFC Heat Transfer Modelling  
(Pharoah-Queen's/FCTL)
  - temperature profiles in tubular SOFC
  - heat recovery system design
  - multi-node computer cluster for large-scale computational problems
- Autothermal Reformer Modelling  
(Peppley-RMC/Harrison, Oosthuizen-Queen's/AUTO21/Questair)
  - temperature profiles, heat transfer and catalytic kinetics
  - reactor design analysis

# Mathematical Modelling

- CFD Modelling of PEM Fuel Cell  
(Peppley-RMC/Karan, McAuley, Oosthuizen and Pharoah-Queen's/DuPont/NSERC)
  - objective is to develop a highly detailed fuel-cell model usable as a design tool
  - Karan, Peppley (1 M.A.Sc) electrode catalysis and kinetics
  - McAuley, Oosthuizen (1 Ph.D.) fluid dynamics down flow-field channel
  - Pharoah (2 M.A.Sc.) gas-diffusion layer and overall model framework.
  - Peppley (1 PDF) experimental fuel-cell design and model validation

# Mathematical Modelling

- Scaling Laws for PEM Fuel Cell  
(Li-Waterloo/DuPont)
  - testing of fuel cells with various size active areas to validate scaling parameters
  - DuPont supplied hardware for experimental investigation

# Manufacturing Cost Modelling

- Process Design Analysis for Flow-Field Plate Manufacturing  
(Frontini, Kennedy-Queen's/DuPont)
  - analysis of economics of manufacturing process options
- Analysis of Alternative Flow-Field Plate Offerings  
(Frontini, Kennedy-Queen's/DuPont)
  - review of patent literature
  - analysis of competitiveness of various flow-field plate materials

# Manufacturing Cost Modelling

- Agricultural Waste Processing for SOFC (Karan-Queen's/BioCap/OMAF)
  - analysis of alternative processing methods for converting agricultural waste to SOFC quality feed
  - process development and technical feasibility analysis

# Ceramics and Nanomaterials

- Low-Temperature SOFCs based on  $\text{CeO}_2$  and  $\text{LaMnO}_3$   
(Krstic[CMACN], Karan -Queen's /FCTL)
  - development and testing of alternate electrolyte materials for SOFCs
- Electrophoretic Deposition of Thin Films for SOFC  
(Petric-McMaster/MMO/FCTL)
  - modification of ceramic materials to improve mass transfer characteristics

# Ceramics and Nanomaterials

- Mesoporous Titanium Oxide as Hydrogen Storage Material (Windsor/MMO/GM)
  - investigation of material properties of  $\text{TiO}_2$  for hydrogen storage

# Catalysis and Reaction Engineering

- Low-Temperature SOFC Feasibility  
(Karan-Queen's)
  - development of SOFC anode catalyst materials
  - measurement of catalyst activity for direct ethanol oxidation
- Autothermal Reformer Development  
(Peppley-RMC/Auto21/Questair)
  - initially intended to use oxygen-enriched air
  - development of high-heat transfer design
  - validation of CFD modelling

# Catalysis and Reaction Engineering

- Fuel Processor Technology Development (Karan-Queen's/Long-Dana Corp.)
  - investigation of methods of integrating reaction and heat exchange operations
  - catalyst and materials evaluation

# Process Development (Computational Thermodynamics)

- Advanced Concepts for Hydride Storage of Hydrogen  
(Davis, Karan - Queen's/NSERC/Auto21/Kingston Process Metallurgy/ DaimlerChrysler)
  - initially looked at borohydride reclamation
  - scope expanded to look for other storage concepts

# CFI Proposal

- Title: Fuel Cell Research and Innovation Centre (same as FCRC)
- Project Leader - Peppley
- Eight co-applicants
  - Amphlett, Bates, Creber, Roberge (RMC)
  - Davis, McAuley, Oosthuizen (Queen's)
  - Li (Waterloo)
- Integrated plan based on Fuel Cell Research needs.
- Written with focus on PEM

# Hydrogen Production and Storage

- Hydrocarbon Reforming Catalyst Test System (RMC)
- Hydrocarbon Reforming Catalyst Characterisation System (RMC)
- Gas Chromatography System (FCRC)
- Hydride Reprocessing Equipment (FCRC)
- Technical support personnel (1)

CFI Infrastructure

# Low-Cost Membrane Development

- Dynamic Mechanical Analyser System (RMC)
- Differential Scanning Calorimeter System (RMC)

# Flow-Field Modelling and Design

- Customised experimental fuel cell and fuel-cell test station (FCRC)
- High resolution impedance spectroscopy system (FCRC)
- Membrane moisture measurement system (FCRC)
- Gas diffusion permeator (FCRC)
- Capillary porometer (FCRC)

# Flow-Field Modelling and Design

- Particle Imaging Velocimeter (PIV) for studying liquid water entrainment and two-phase flow (FCRC)
- UNIX workstation (Waterloo)
- Automated fuel-cell test station (Waterloo)
- Technical support personnel (2)

# Flow-Field Modelling and Design

- CNC milling machine (FCRC)
- 100 ton compression molding press and mold heating equipment (FCRC)
- Infrared mold imaging equipment (FCRC)
- Technical support personnel (1)

# Fuel Cell Testing and Reliability Studies

- Custom configured fuel-cell test station (FCRC)
- Impedance spectroscopy analysis system (FCRC)
- Technical support personnel (1)

# Conclusions

- Broad range of research activities are already in progress
- Comprehensive range of core expertise
- Infrastructure to be added will significantly enhance research capabilities