FC052

Technical Assistance to Developers

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2013 DOE Hydrogen and Fuel Cells Program and Vehicles Technologies Program Annual merit Review and Peer Evaluation Meeting
May 13-17, 2013
Arlington,VA.

Overview

- **Timeline**
  - Start: 10/03
  - End: ongoing
  - % complete: N/A
- **Budget**
  - FY12 $450K/y
  - FY13 $300K/y
    - DOE share: 100%
    - Contractor share: N/A
- **Barriers**
  - Sharing technical assistance to developers
  - A. Durability
  - B. Cost
  - C. Electrode performance
- **Partners/Collaborators**
  - See list on right for FY13

Approach for Technical Assistance

This task supports Los Alamos technical assistance to fuel-cell component and system developers as directed by the DOE. This task includes testing of materials and participation in the further development and validation of single cell test protocols. This task also covers technical assistance to Durability Working Groups, the U.S. Council for Automotive Research (USCAR) and the USCAR/DOE *Driving Research and Innovation for Vehicle efficiency and Energy sustainability* (U.S. Drive) Fuel Cell Technology Team. This assistance includes making technical experts available to DOE and the Fuel Cell Tech Team as questions arise, focused single cell testing to support the development of targets and test protocols, and regular participation in working group and review meetings. **Assistance available by Request and DOE Approval.**

2013 Collaborators and Activities

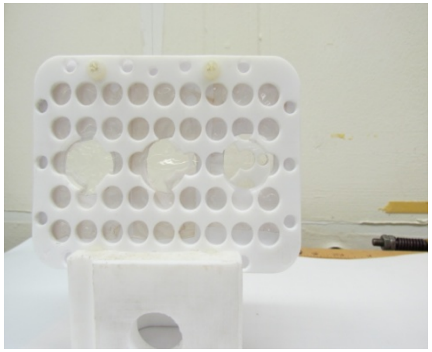
- **NIST**
  - Bipolar Plates; probing the impact of flow field inaccuracies on FC performance
  - Neutron Imaging
- **DOE Fuel Cell Technologies Transport Modeling Working Group**
  - R. Mukundan serving as the co-chair
- **DOE Fuel Cell Technologies Durability Working Group**
  - R. Borup serving as the co-chair
- **Allen University, Morehouse College, Prairie View A. & M., Southern University A. & M., and Tennessee State University**
  - Hosted 3-day Fuel Cell short course
  - Fuel cell lab set-up and equipment calibration at Colleges and Universities.

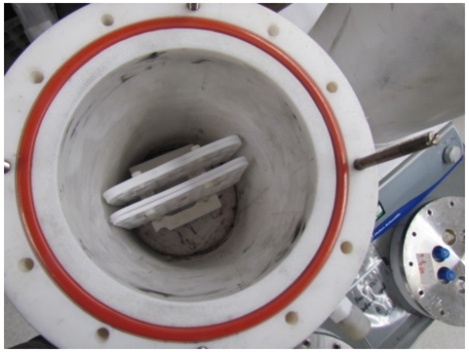
- **SGL Technologies**
  - Novel MPL/GDL Materials
- **Fuel Cell Technologies**
- **General Motors**
  - Water transport properties in membranes
- **Fuel Cell Tech Team**
  - Active participation, R. Borup Member
- **Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)**
  - Evaluation of membrane
  - Materials characterization.

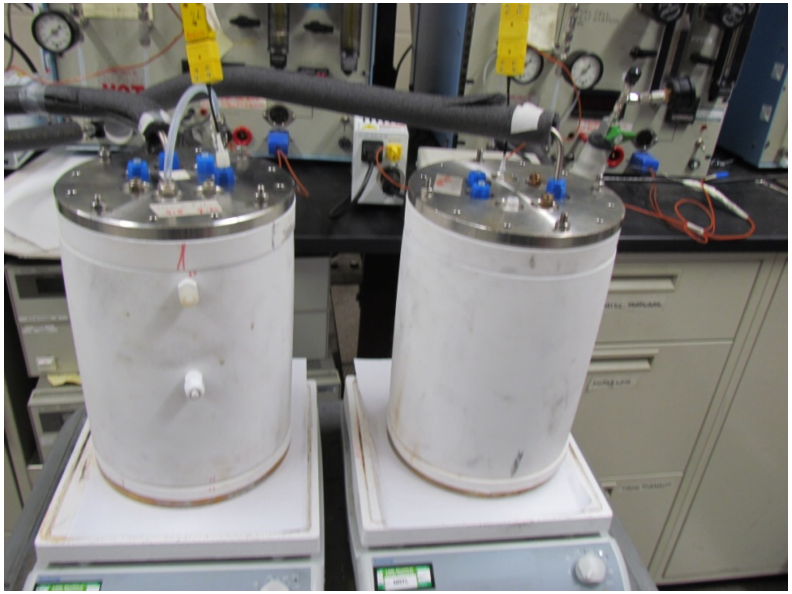
Technical Accomplishments

Examining Degradation of Water Transport in Membranes

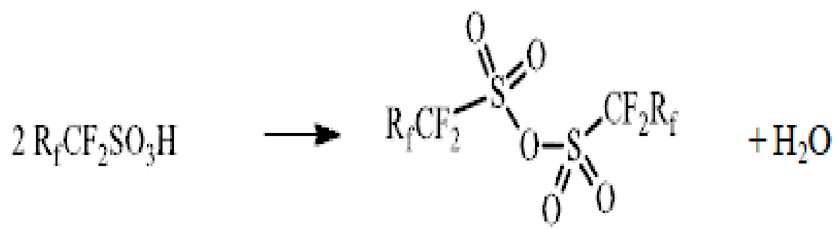
Membrane sample holder and environmental RH Chambers

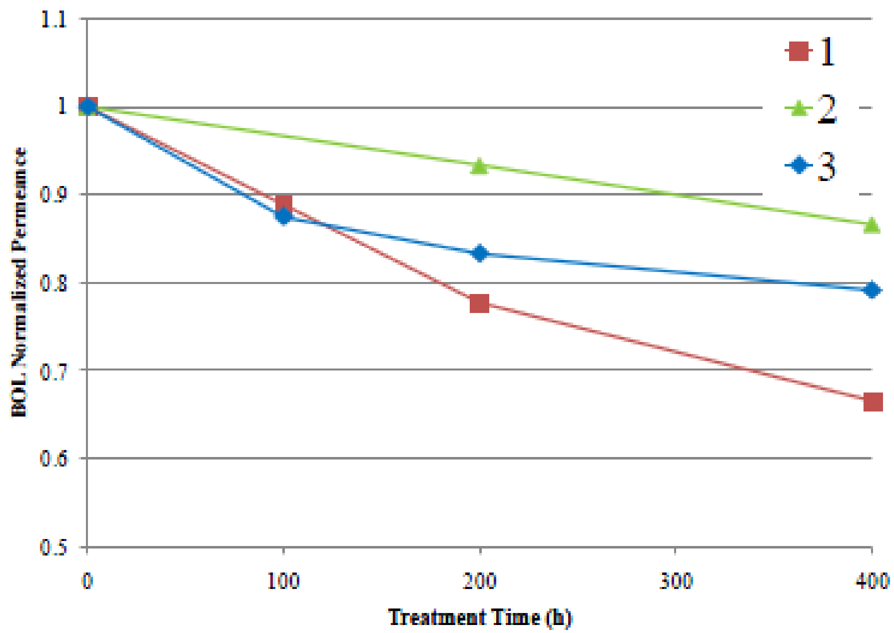






Time Evolution of Membrane Permeance of Various Water Transport Membranes*

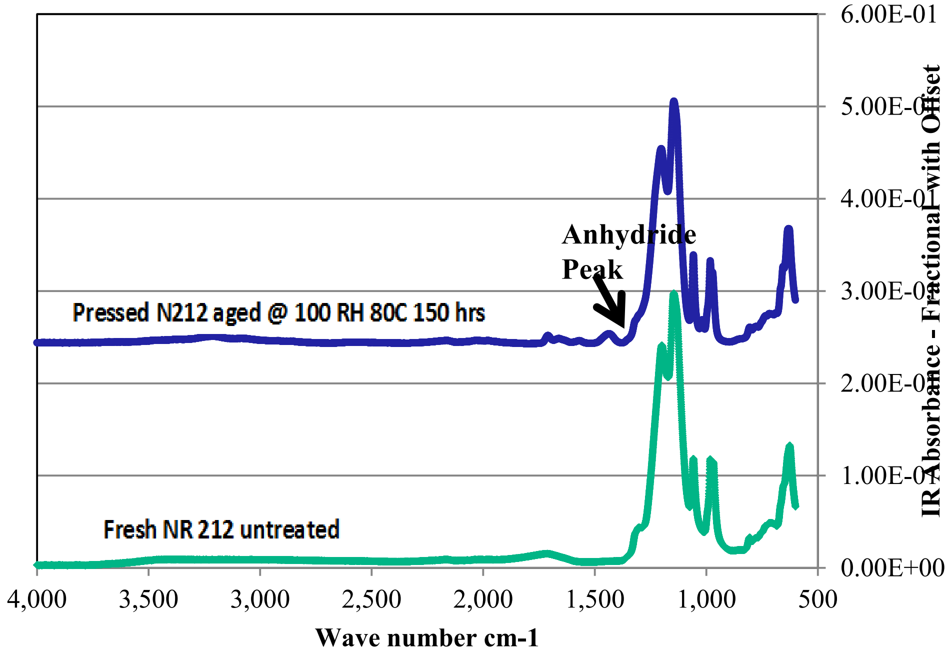




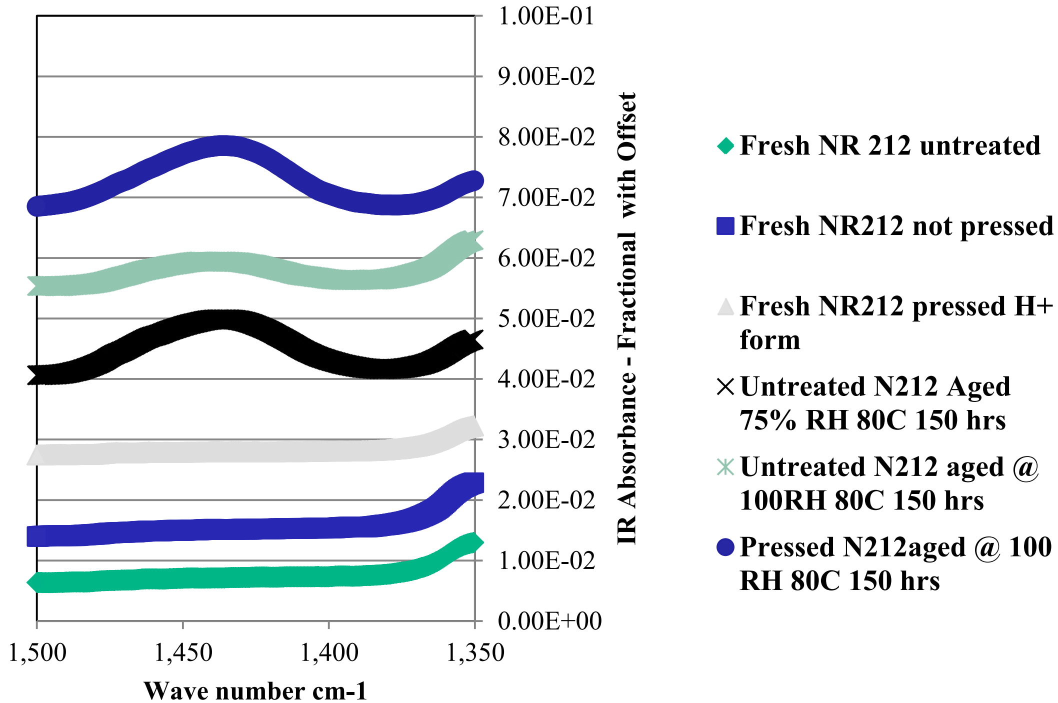
*Clapham, Coms, Fuller and Zou, 212[th] meeting of ECS, 2012

Water transport membranes (used for fuel cell membrane humidifiers) show decreasing water vapor transport properties with time. This has been assigned to anhydride formation in the membranes.

Using FTIR to Examine Chemical Changes in Membrane



Examining Aging Conditions and Processing Conditions



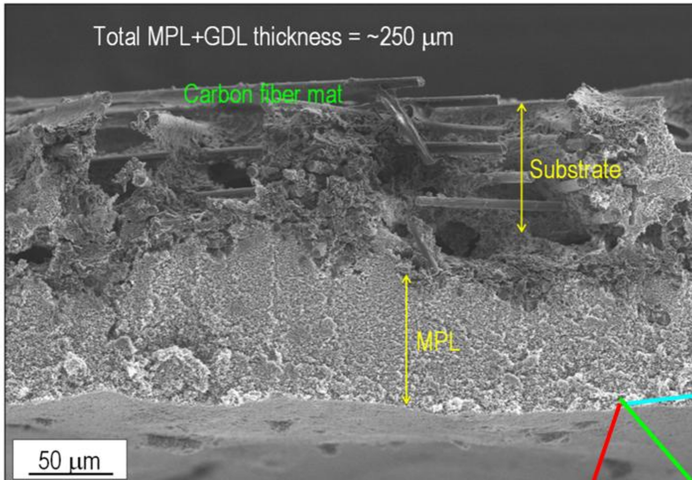
- Pre-treatment of membranes show no significant differences in anhydride formation
- Higher RH (100% vs. 75%) shows slower formation of anhydride
- Plans to examine other materials, active hydride reagent (H_2O_2, O_2, H_2O), O_2 vs. N_2, ionomer materials, and mitigation methods

Novel GDL materials for improved water management and durability

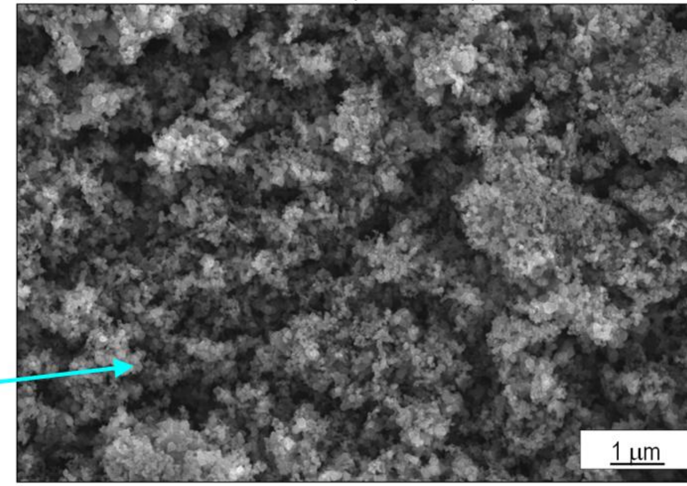
Additives in the MPL (Micro-porous Layer)

LANL, SGL Carbon, Oak Ridge National Laboratory, and NIST

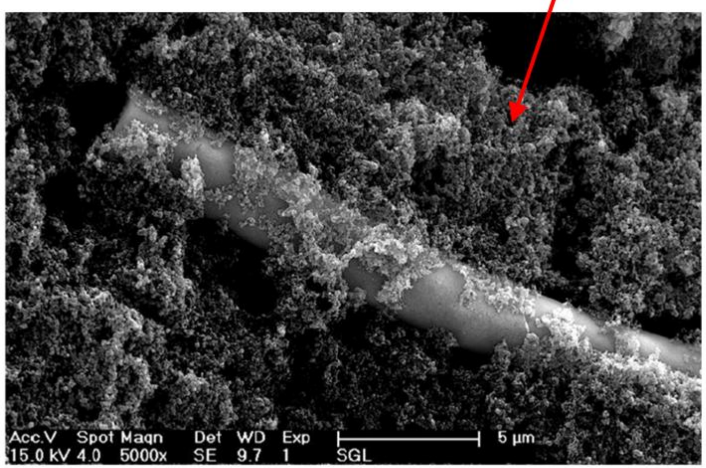
SEM Images of Novel GDL Materials



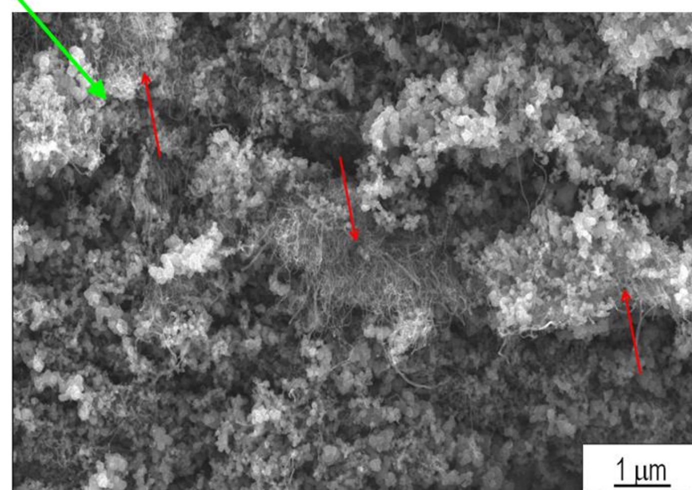
MPL is "loosely packed " carbon black + PTFE; Substrate is carbon fiber mat "filled" with PTFE



MPL is comprised of "loosely packed" carbon black with 23%wt. of PTFE binder



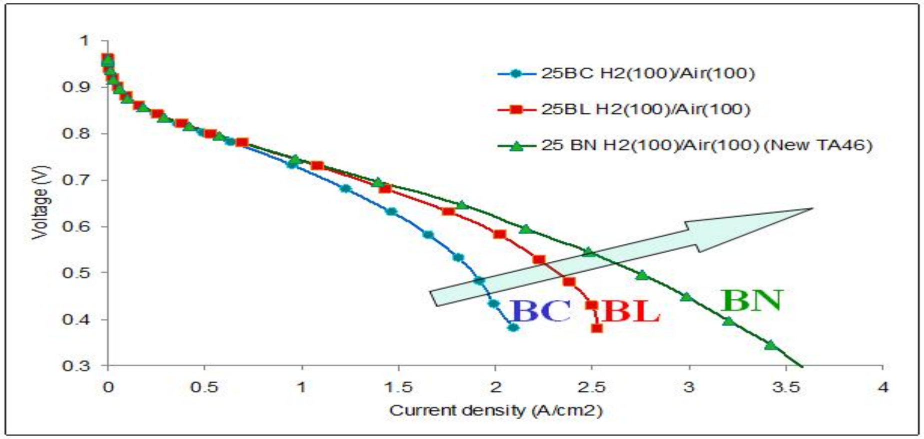
10% Aluminosilicate fibers mixed in with standard MPL mixture of carbon black + PTFE (23w%). MPL treated at 350 °C

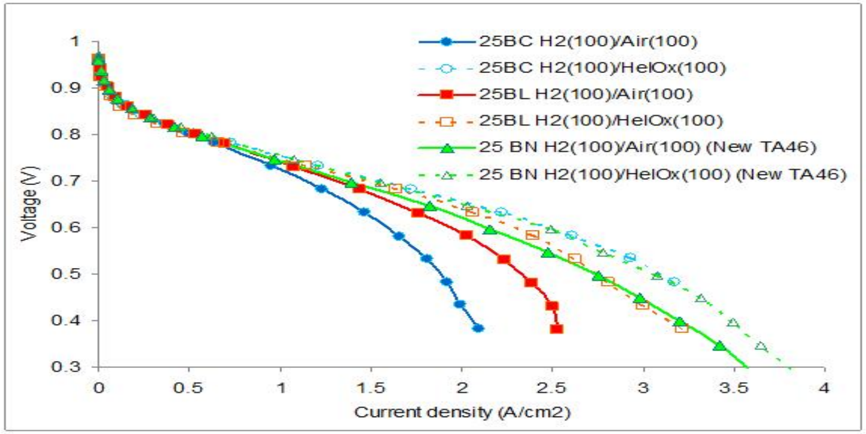


MPL comprised of loosely packed carbon black particles that surround CNT "bundles" (red arrows) – CNTs are not homogeneously distributed within the MPL.

Fuel Cell Performance of BC vs. BL vs. BN GDLs

Vary Cathode MPL (same carbon-fiber substrate). Anode GDL unchanged.



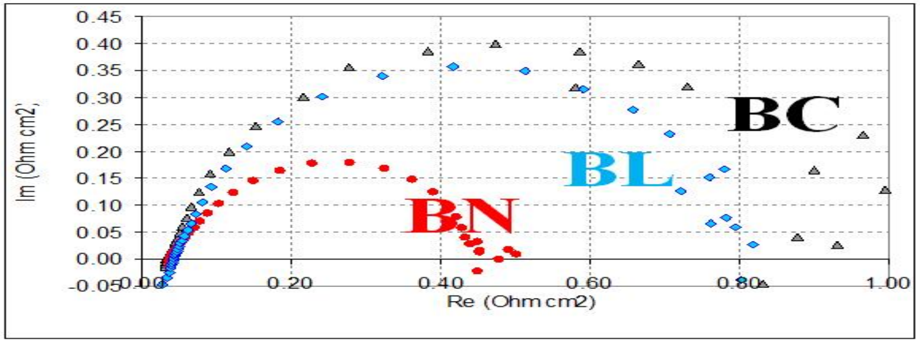


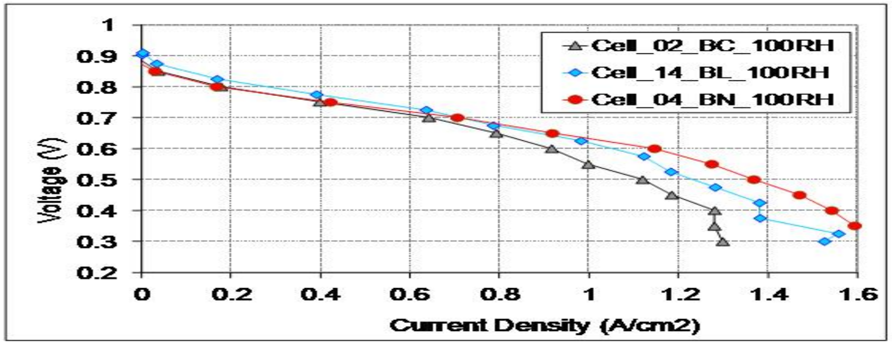
Performance improvement at high current for 25BL and 25BN in H_2/ Air.
Similar performance for 3 GDLs in H_2/ HelOx (O_2 diffuses 3.7x faster in He vs. N_2)

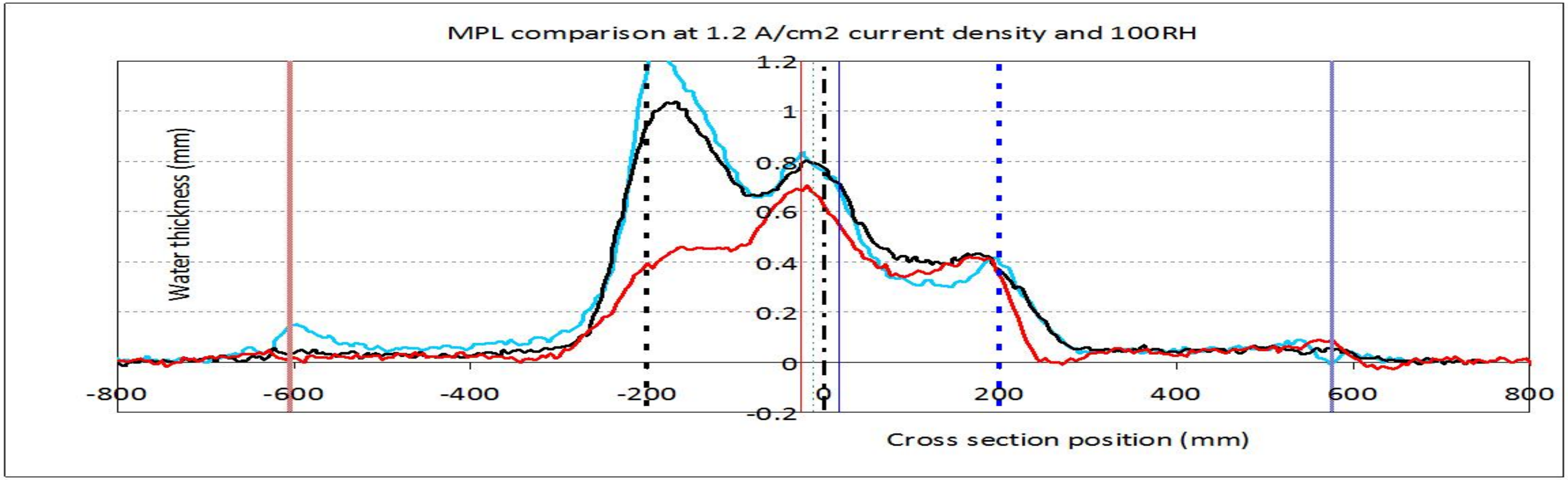
- **25BC** = standard MPL (carbon+PTFE+binder) BASELINE
- **25BL** = standard MPL with hydrophilic treatment: Mass-transport improvement; Durability issues
- **25BN** = standard MPL with C-nanotubes: More mass-transport improvement; Durability good

50 cm² cell, quad serpentine, MEA = Gore PRIMEA A510.2/M710.18/C510.4; 80° C, 100% RH, 1.2/2 stoich, 28.4 psi backpressure

Impedance Spectra and Water Profiles at 1.2 A/cm²







- Results show difference in performance as the current increases (i.e. Mass Transport Region)
- Higher current may have some effect of internal heating at lower V.
- Rationale for better performance of the BN is likely due to less flooding in the cathode catalyst layer.

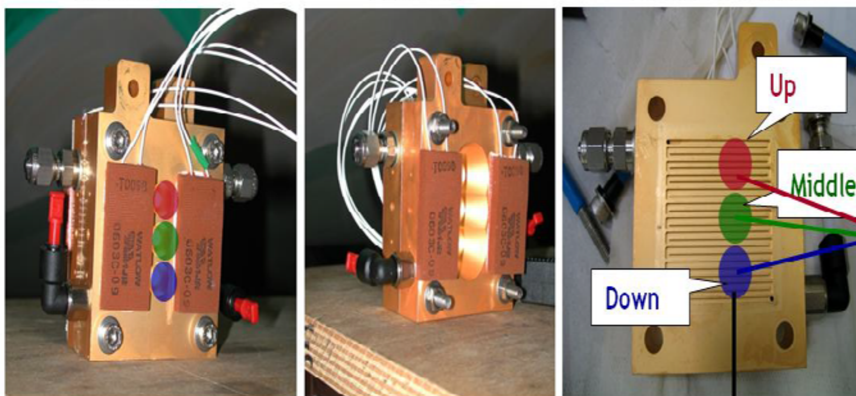
Evaluation of Membrane water content evolution, transport properties, repartition *ex-situ* and during PEMFC operation

Single Cell Test Fixture for SANS

25 cm² golded alumium cell

- End plates = monopolar plates
- Single machined serpentine channel

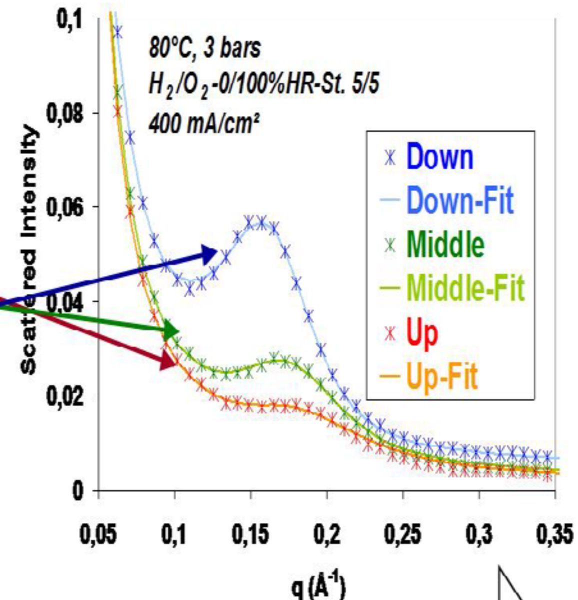
Cathode side | Anode side | Flow field channel



- Co-flow configuration
- Probe 3 areas: - Up (≅ Inlet)
  - Middle
  - Down (≅ Outlet)

Φ~10 mm
Average on
~ 5 rib/channels

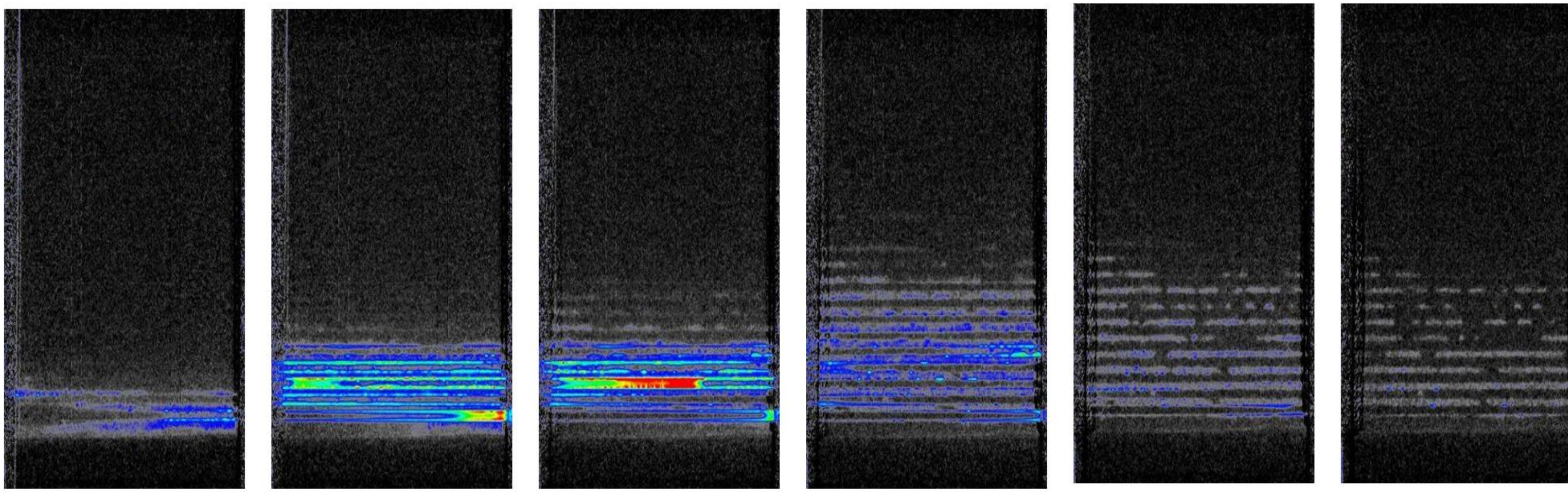
Average membrane water content



Water concentrations measured *in-situ* by SAXS are qualitative; to quantitate the water concentration, CEA cell was operated using neutron imaging

LANL-CEA-NIST Interaction

Neutron Imaging of Water Concentration vs. Current Density



0.1 A/cm^2 0.2 A/cm^2 0.4 A/cm^2 0.6 A/cm^2 0.7 A/cm^2 0.8 A/cm^2

- SANS and neutron imaging show maximum cell water content between 0.2 – 0.4 A/cm^2, above this current density the heat generated in the cell reduces the water content.
- SANS shows that the membrane water content below the ribs is greater than that below the channels. This is consistent with higher resolution through plane neutron imaging.
- The co-flow cells have maximum water content near the outlets and the counter flow cells have maximum water content near the middle of the cells.

LANL Facilities Available for Technical Assistance to Developers

Fuel-Cell Materials and Testing. Los Alamos has experimental equipment for fuel-cell testing and characterization

Material characterization equipment including:

- Scanning electron microscopy/energy dispersive X-ray analysis,
- X-ray fluorescence spectroscopy
- Differential scanning calorimetry
- Fourier transform infrared (FTIR) spectroscopy
- TEOM (tapered element oscillating microbalance)
- Thermogravimetric analysis (TGA)
- Simultaneous TGA/DSC
- Differential thermal analysis (DTA)
- Solid-phase and liquid-phase NMR
- Gas chromatography
- Mass spectroscopy
- X-ray diffraction
- Solid-state DRIFTS
- Raman spectrometer
- Electron beam evaporation
- RF magnetron sputtering
- AC impedance spectroscopy
- BET surface area measurements

DOE Working Groups

1. **Durability Working Group meetings:**

    May 2012

    Borup presented and co-chaired the meeting.

    October 2012 at ECS

    Borup and Mukundan presented and Borup co-chaired

    Feb 2013 in D.C.

    Borup and Mukundan presented three presentations and Borup co-chaired and facilitated breakout session

2. **Transport Modeling Working Group - 2nd Meeting**

    March 1 2013 in D.C.

    Mukundan co-chaired

    Borup facilitated section and presented at the breakout session

3. **Fuel Cell Tech Team** –

    R. Borup Member

Hands-On Fuel Cell Short Course January 2013

• Participants from Allen University, Morehouse College, Prairie View A. & M., Southern University A. & M., and Tennessee State University

Future Work to be Defined by DOE

Acknowledgements

LANL acknowledges The US DOE Office of Fuel Cell Technologies and Technology development manager: **Nancy Garland** for their support.