Resolution of PEM Fuel Cell Membrane Hydration by Neutron Imaging

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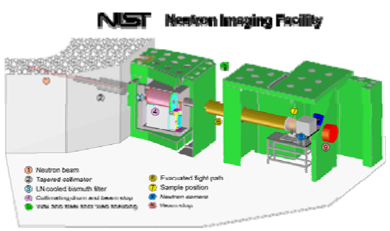
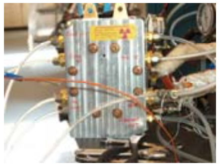
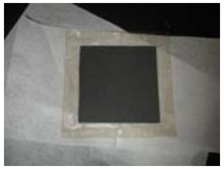
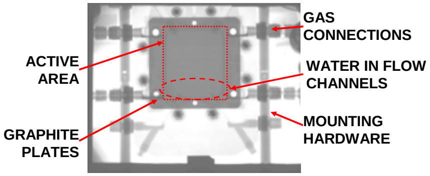
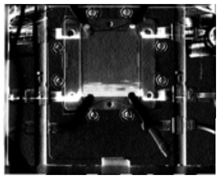


- It has been shown in the past that liquid water is easily detected within fuel cell flow channels (Bellows et al., 1999). This study displays the ability to resolve changes in water content within the membrane and gas diffusion layers alone.
- Hydration of the perfluorosulfonic acid based fuel cell membrane is critical to maintaining maximum proton conductivity and, thus, fuel cell performance.









- Comparative image processing results in the isolation of water within the fuel cell.
- By dividing a “wet” image with a “dry” image the dry contribution drops out of the exponent resulting the isolation of water.

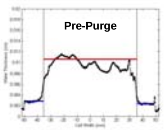
$$I = I_o \exp\left(-\sum N\sigma t\right)$$

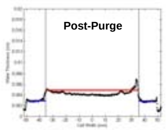
$$I/I_{drycell} = \exp\left(-N_{water}\sigma_{water}t_{water}\right)$$

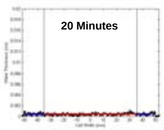
$$D = -\ln\left(I/I_{drycell}\right) = N_{water}\sigma_{water}t_{water}$$

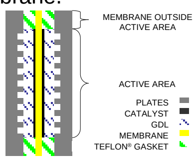
$$t_{water} = D/N_{water}\sigma_{water}$$

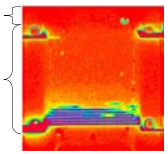
- Neutron imaging provides the ability to measure membrane hydration in a distributed sense.
- The high depth and time resolution provides the ability to study diffusion and exchange rates of the membrane.

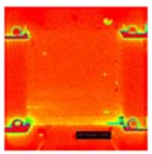


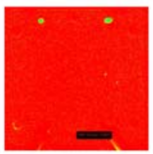


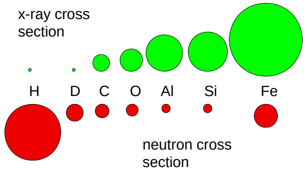




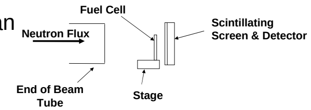








- Hydrogen has a neutron scattering cross section significantly larger than other materials within a fuel cell. Areas of high hydrogen concentration can be found by detecting the neutron flux attenuation.

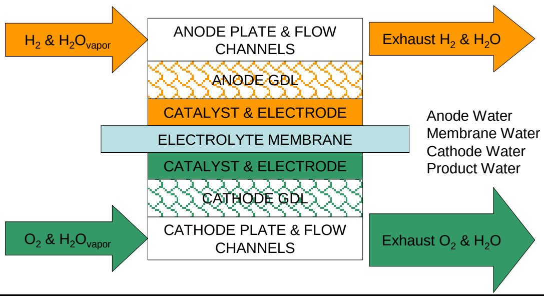


FUTURE WORK

Isolation of Water “Type” by use of Deuterium

- Deuterium does not have the same neutron scattering cross-section as Hydrogen, though it does behave chemically the same.
- Proof-of-concept experiments:
  - Compare neutron imaging results of D_2O and H_2O hydrated membranes
  - Record transient dehydration of D_2O hydrated membrane
- Various combinations of deuterium and hydrogen will isolate the behavior of water sources of interest.

Exp#	Humidification				Fuel		Membrane Hydration		Expected Results
	Anode		Cathode						
	H_2O	D_2O	H_2O	D_2O	H_2	D_2	H_2O	D_2O	
A	■			■		■		■	•Exchange of anode humidification with membrane water •Progression of anode humidification across the cell
B		■	■			■		■	•Back Diffusion of cathode humidification •Exchange with membrane water
C		■		■	■			■	•Product water only •Back diffusion and exchange with membrane water
D		■		■		■	■		•Exchange of initial membrane water over time



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