Insights into the Water Management Problem of PEFCs Provided by Neutron Imaging

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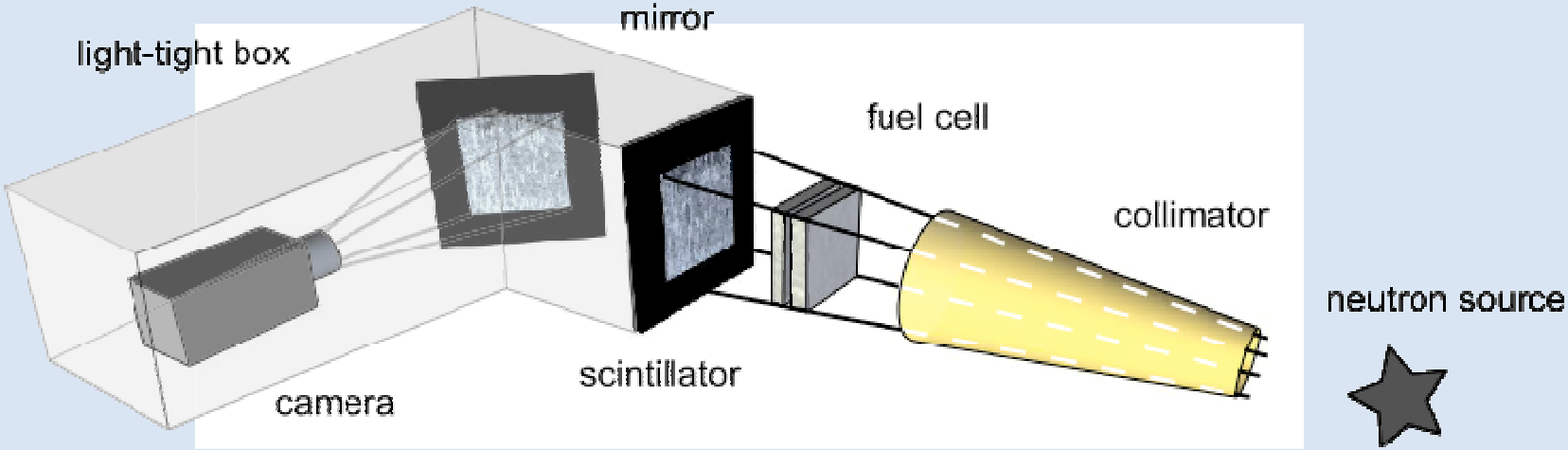
Neutron radiography – Experimental setup



1. The collimated neutron beam becomes attenuated while passing through the cell, depending on the local presence of attenuating material
2. By hitting the scintillator the attenuated beam evokes the irradiation of light
3. The resulting optical image is recorded after reflection on a mirror

A. Geiger et al., Fuel Cells 2 (2002) 92

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Advantages of Neutron Imaging

- Good Transparency for Structural Materials
- High Contrast for Water
- Isotopic Sensitivity

Limitations:

- Spatial and Temporal Resolution

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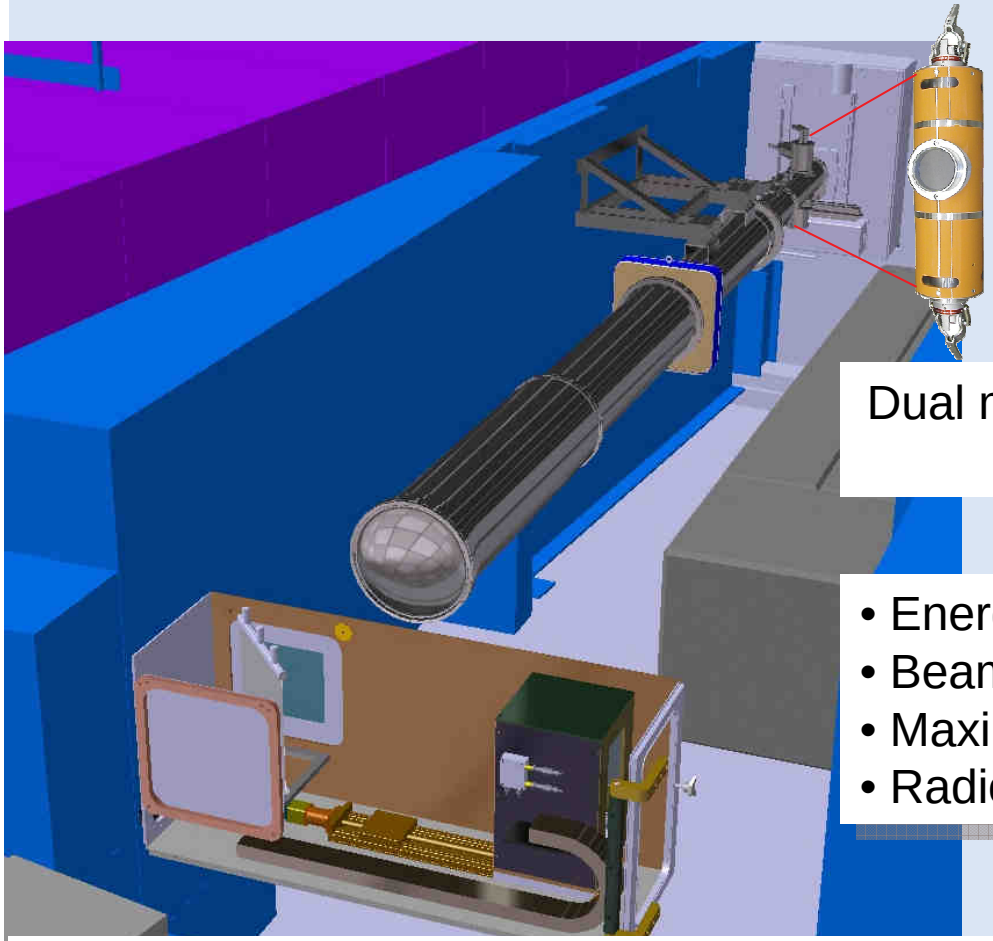
NEUTRA: thermal neutron radiography beamline



Dual modality imaging with 320 kV X-ray tube
XTRA-option

- Energy spectrum: Thermal Maxwellian
- Beam collimation ratio L/D: 550
- Maximum field of view: 340 x 340 mm
- Radiography of highly radioactive samples

CCD camera on linear table for variable size field of view

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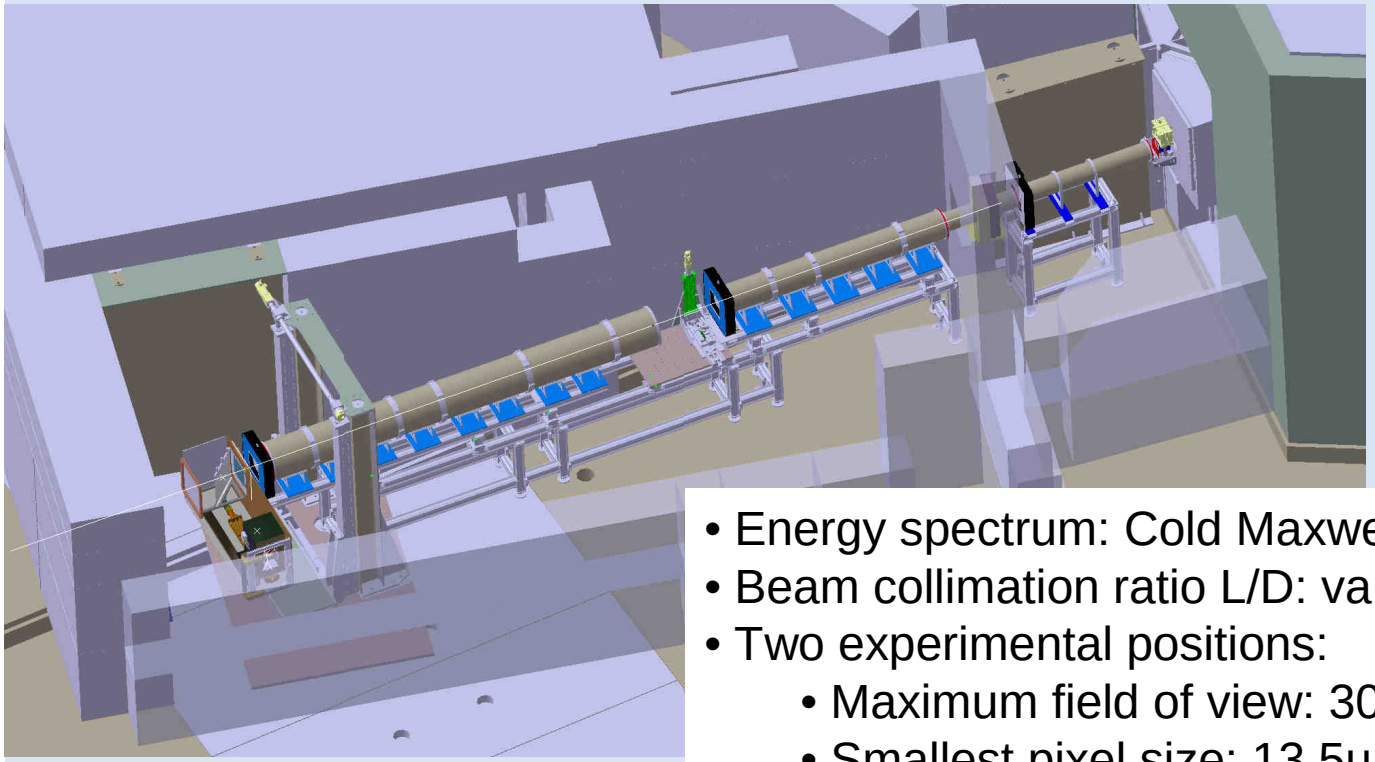
ICON: Cold neutron imaging beamline



- Energy spectrum: Cold Maxwellian
- Beam collimation ratio L/D: variable (max 10000)
- Two experimental positions:
  - Maximum field of view: 300 x 300 mm
  - Smallest pixel size: 13.5µm
- Radiography and tomography
- Energy selective imaging
- Infrastructure to handle up 500kg samples

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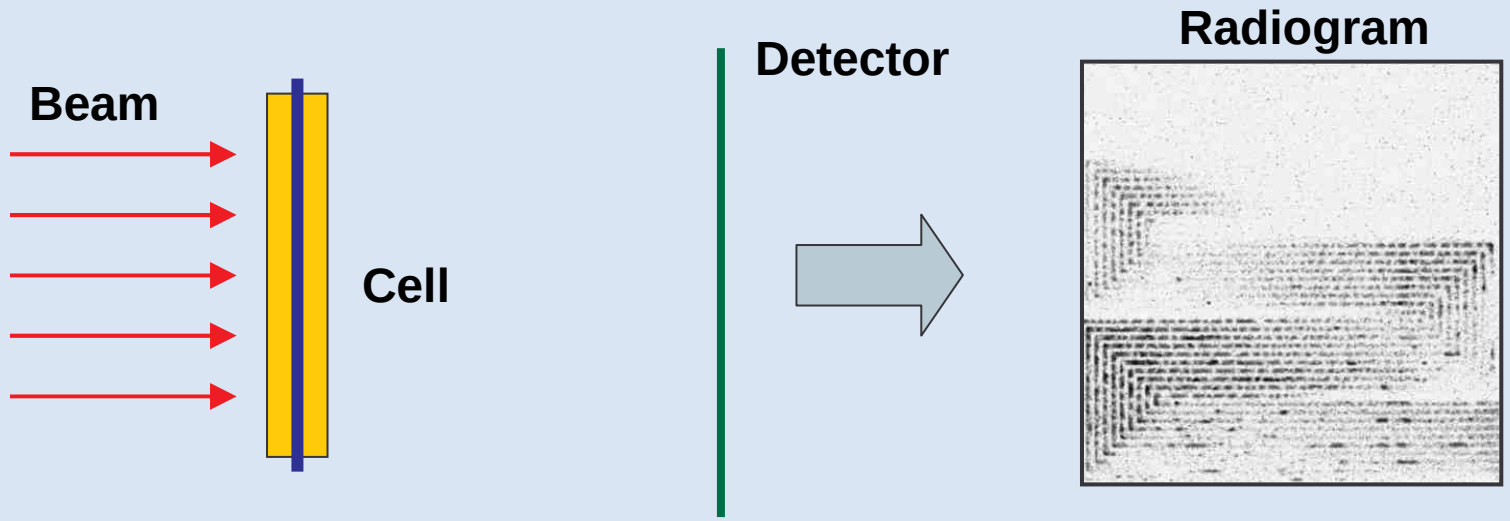
Through Plane Imaging



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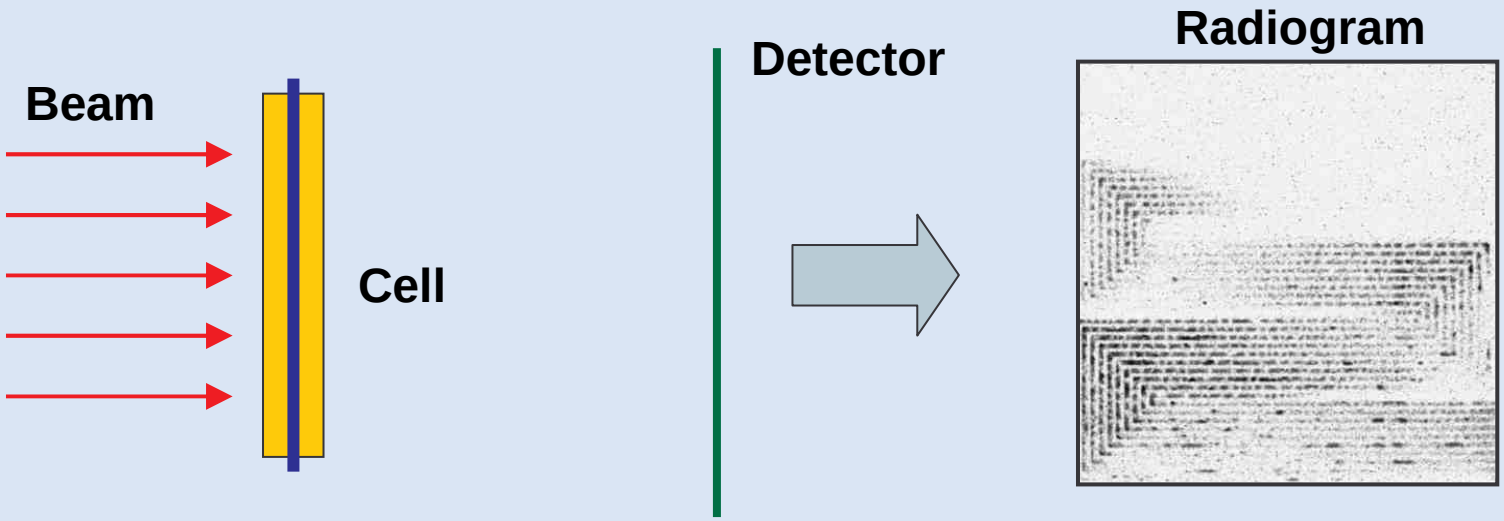
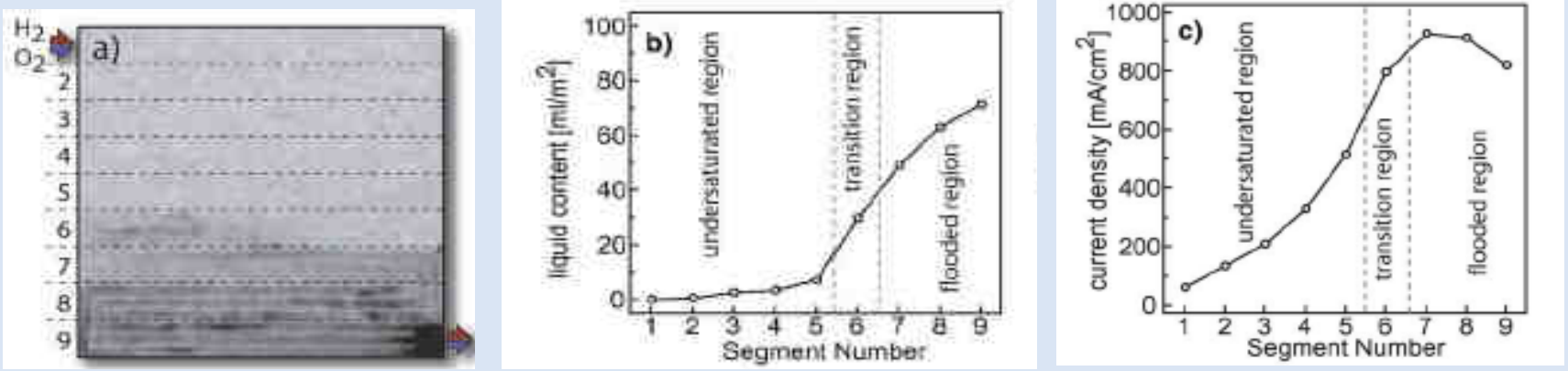
Through Plane Imaging

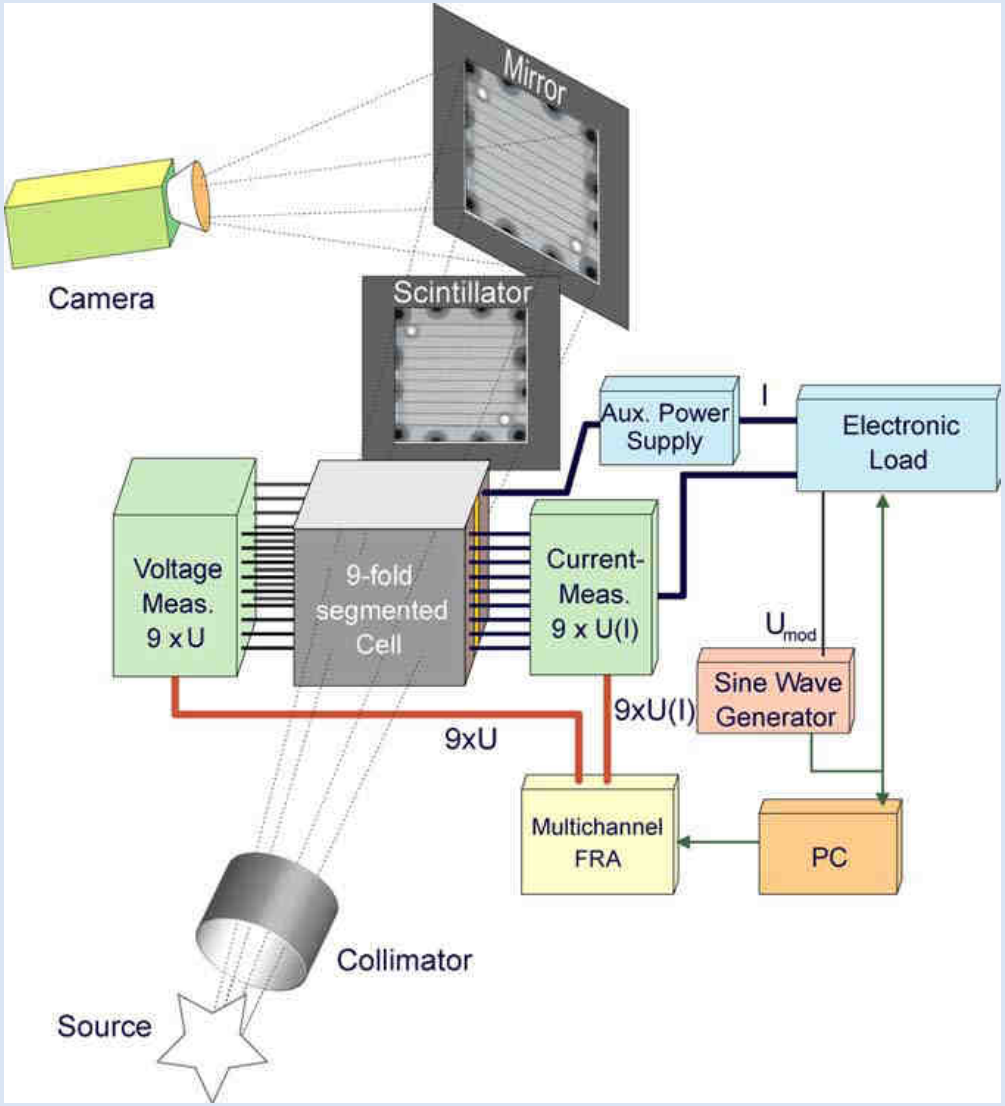


Example: Combination with locally resolved measurements



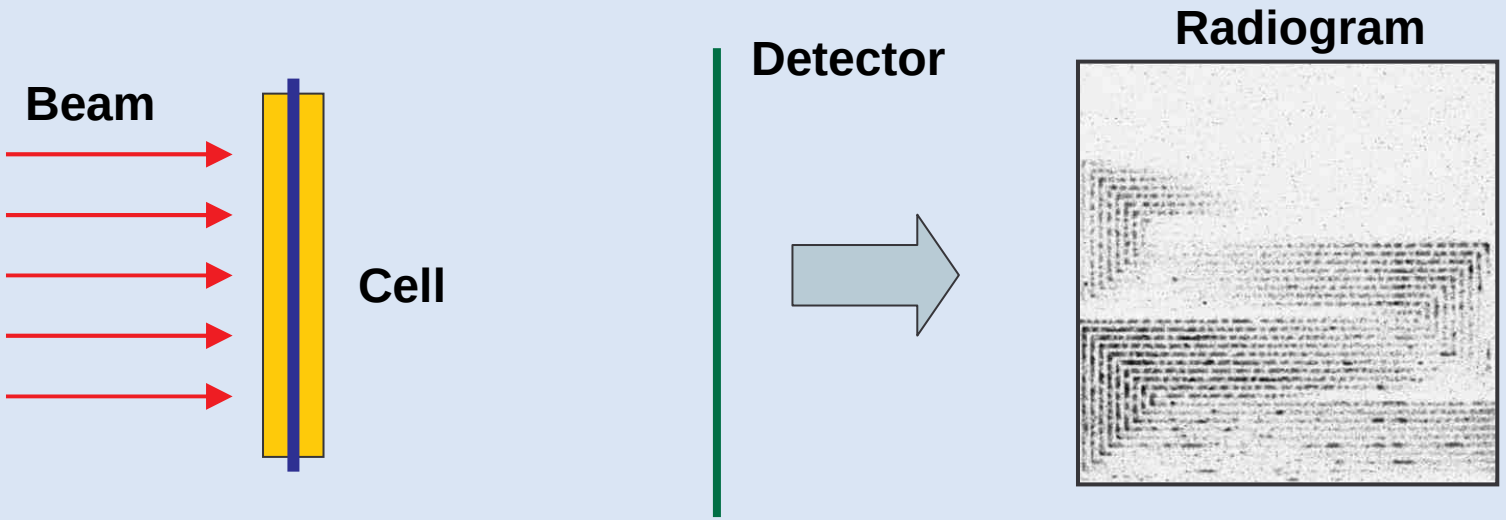
I.A. Schneider, D. Kramer, A. Wokaun, G.G. Scherer, Electrochem. Commun. **7**, 1393 (2005)

NI in combnation with locally resolved EIS, CV,others

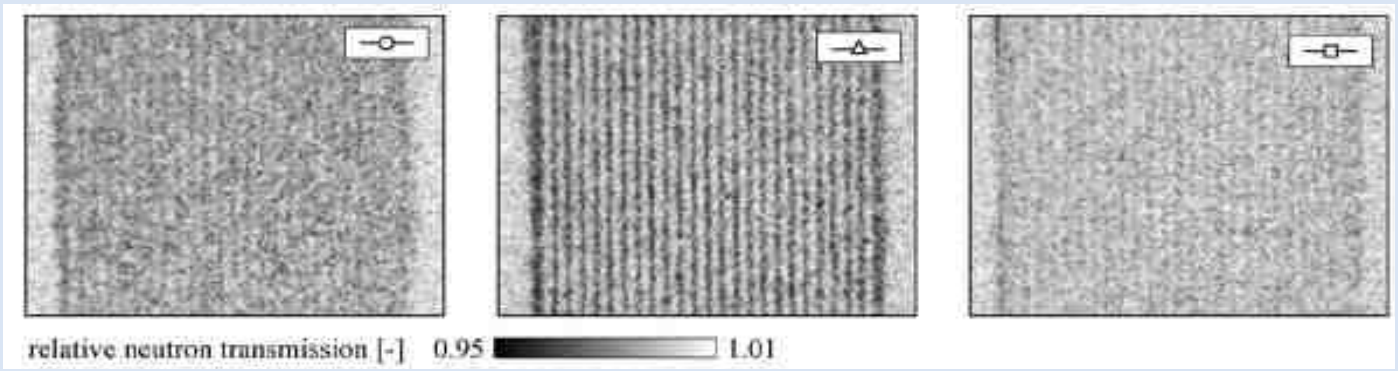


I.A. Schneider, D. Kramer, A. Wokaun, G.G. Scherer,
Electrochem. Commun. **7**, 1393 (2005)
I.A. Schneider, G.G. Scherer
Fuel Cell Handbook, Vol. 5&6, Chapter 45 (2009)

Through Plane Imaging

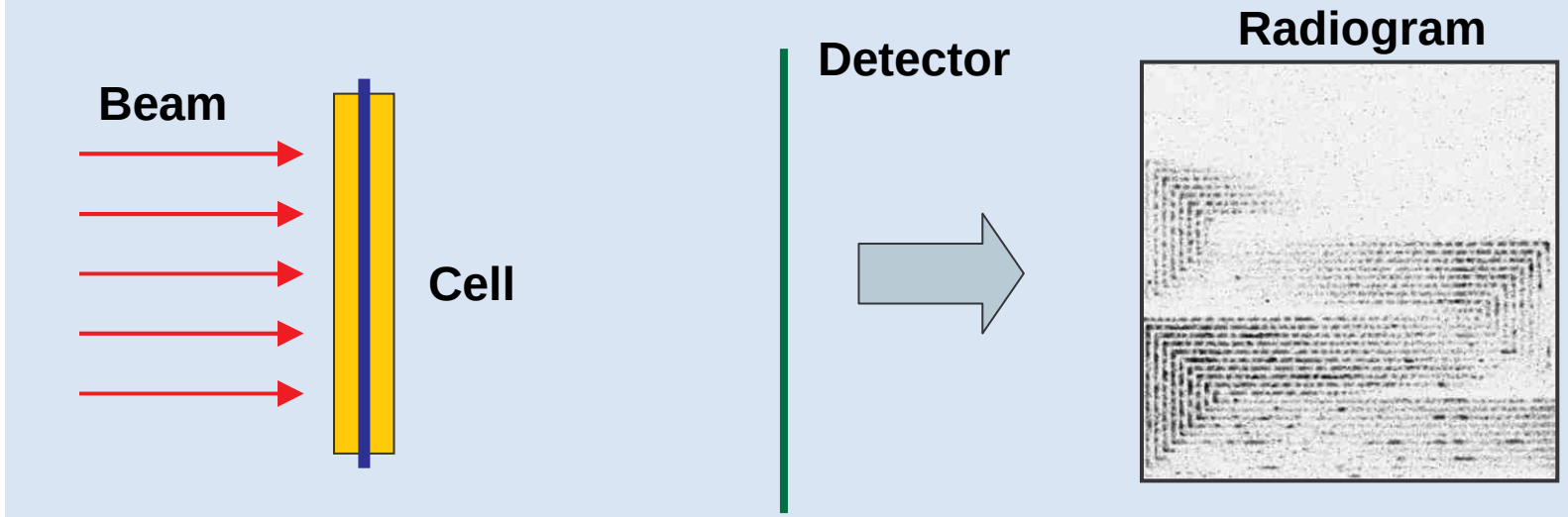


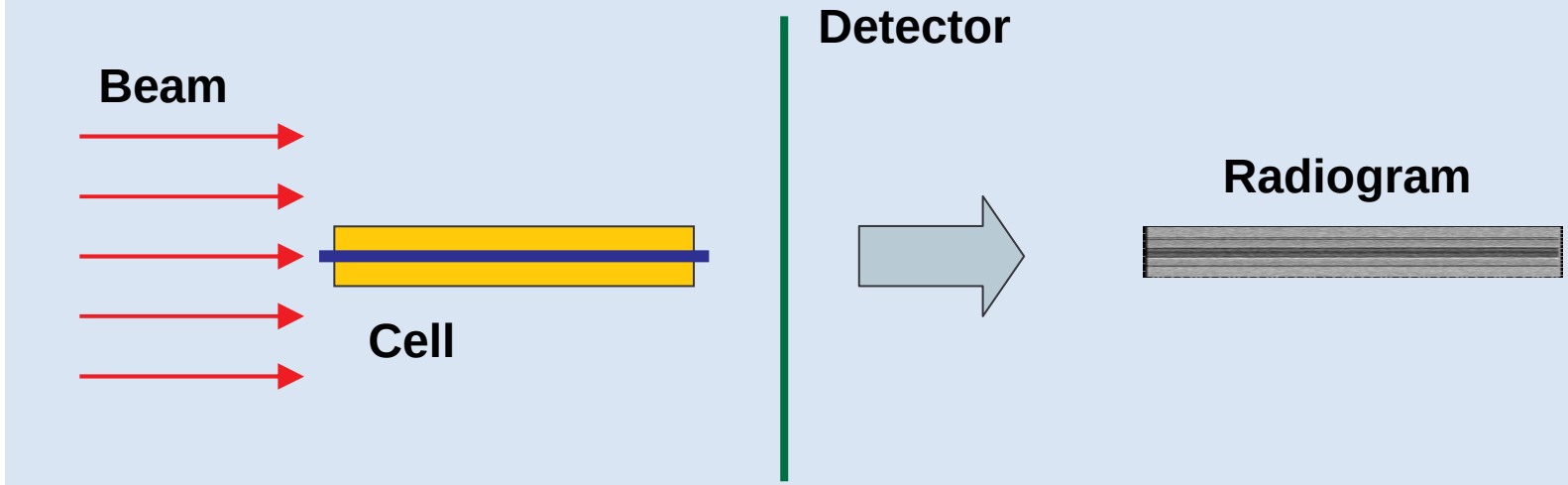
Example: Effet of different GDL materials on water distribution



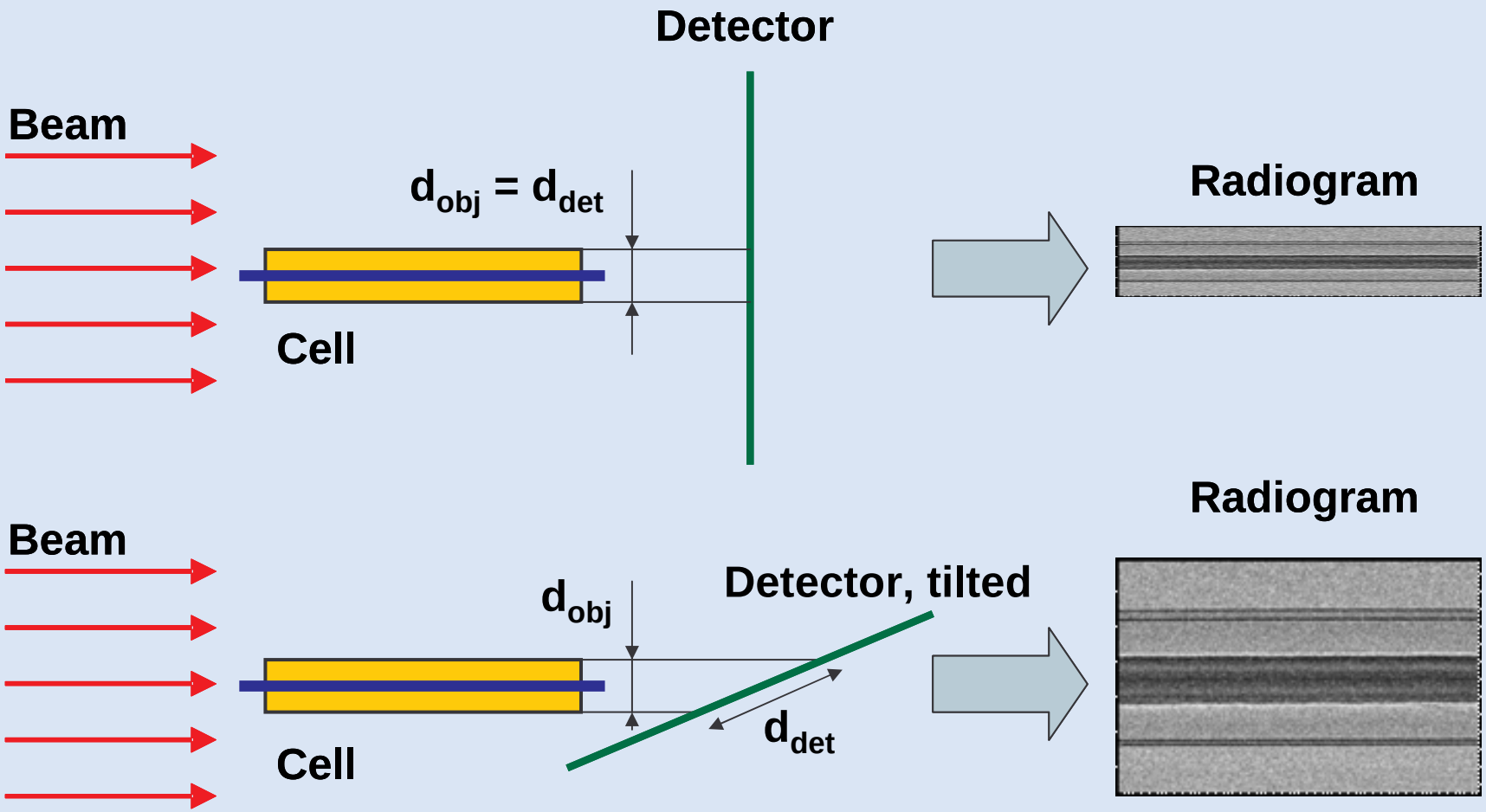
J. Zhang, D. Kramer, R. Shimoi, Y. Ono, E. Lehmann, A. Wokaun, K. Shinohara, G.G. Scherer, Electrochimica Acta **51**, 2715 (2006)

Through Plane and *In Plane* Imaging



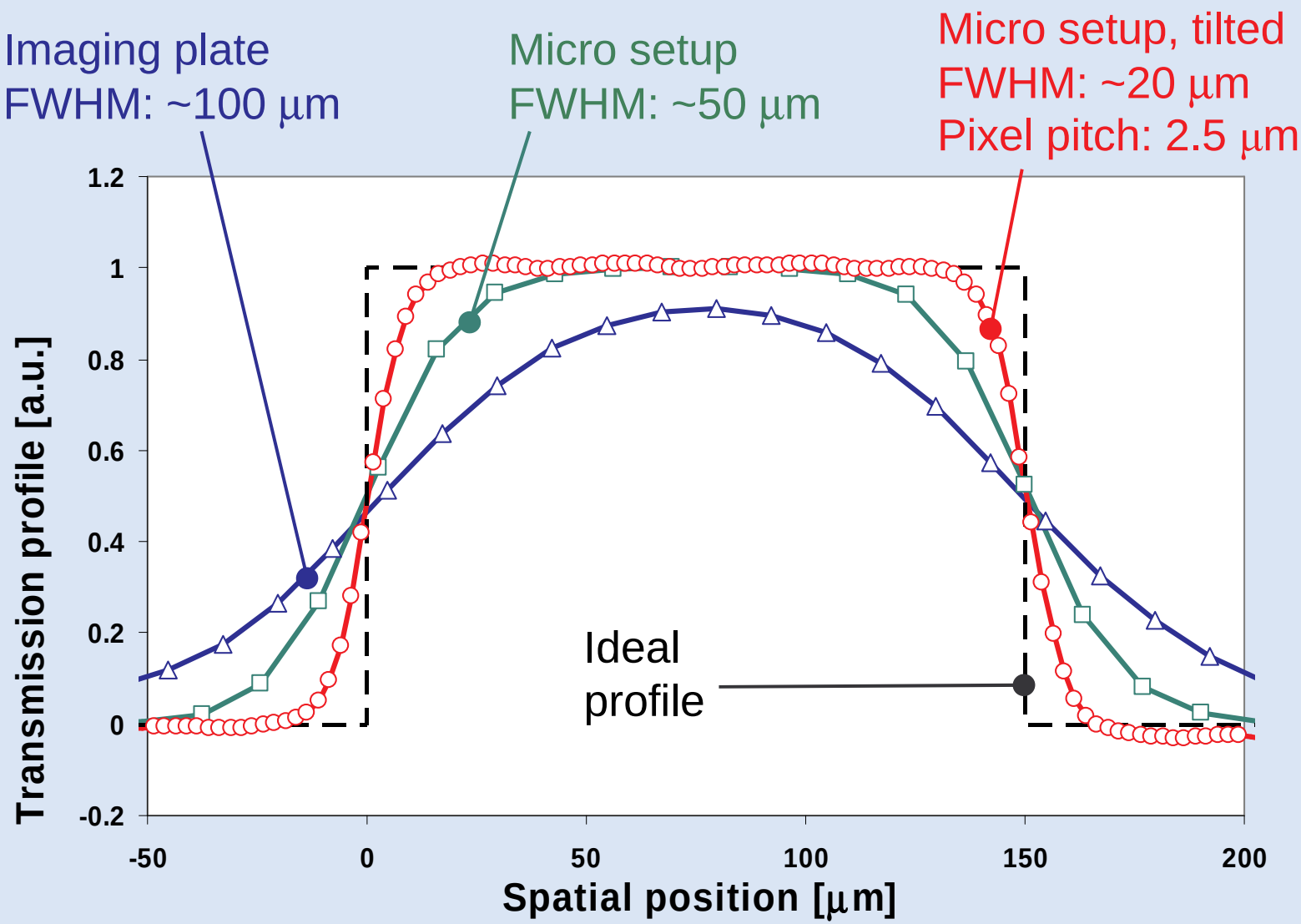


Detector improvement



P. Boillat, D. Kramer, B.C. Seyfang, G. Frei, E. Lehmann, G. G. Scherer, A. Wokaun, Y. Ichikawa, Y. Tasaki, K. Shinohara, Electrochemistry Communications **10**, 546 (2008)

Detector improvement - Results



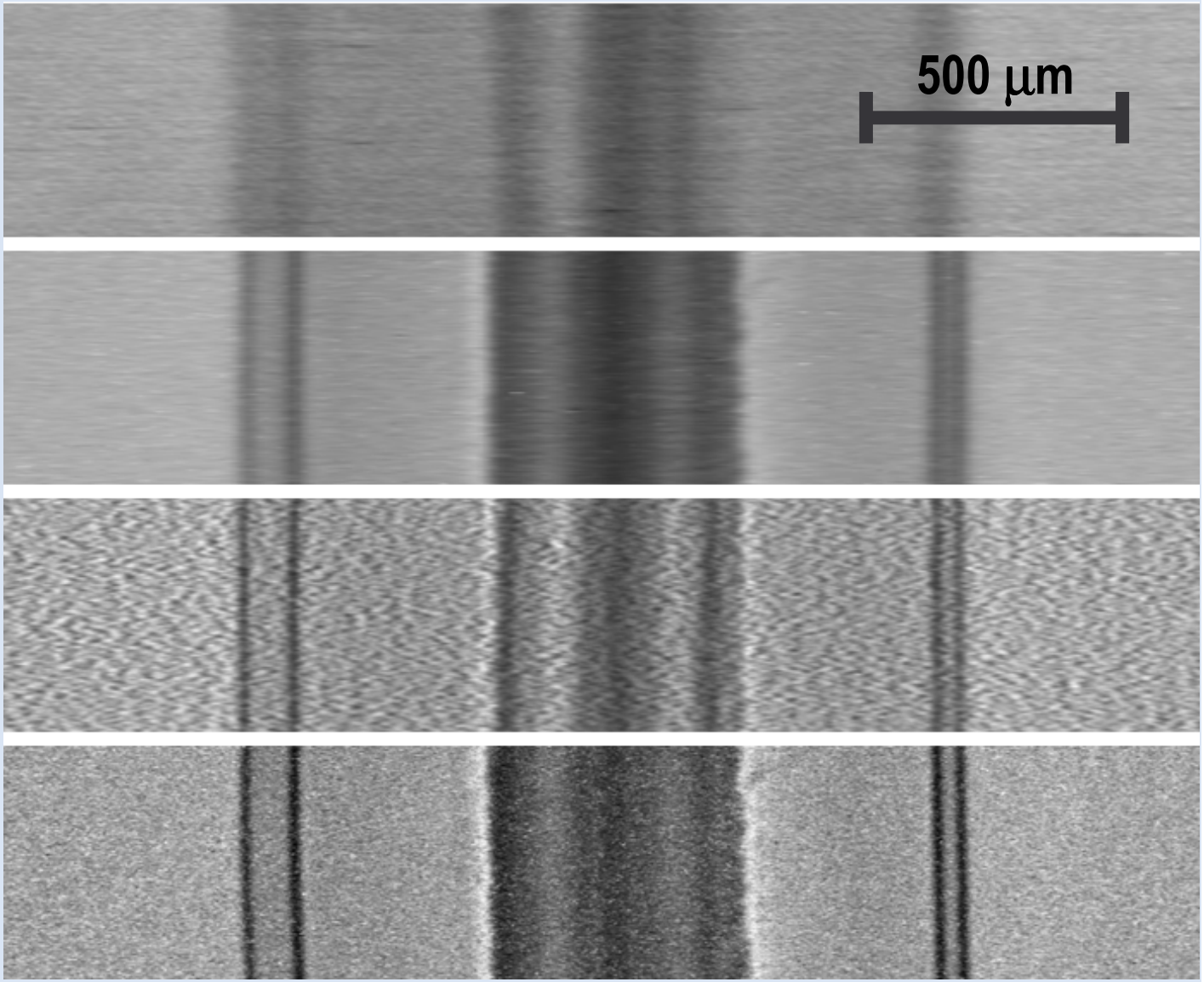
Examples: Images of Dry Fuel Cells

Imaging Plate

Micro Setup

Imaging Plate, Tilted

Micro Setup, Tilted



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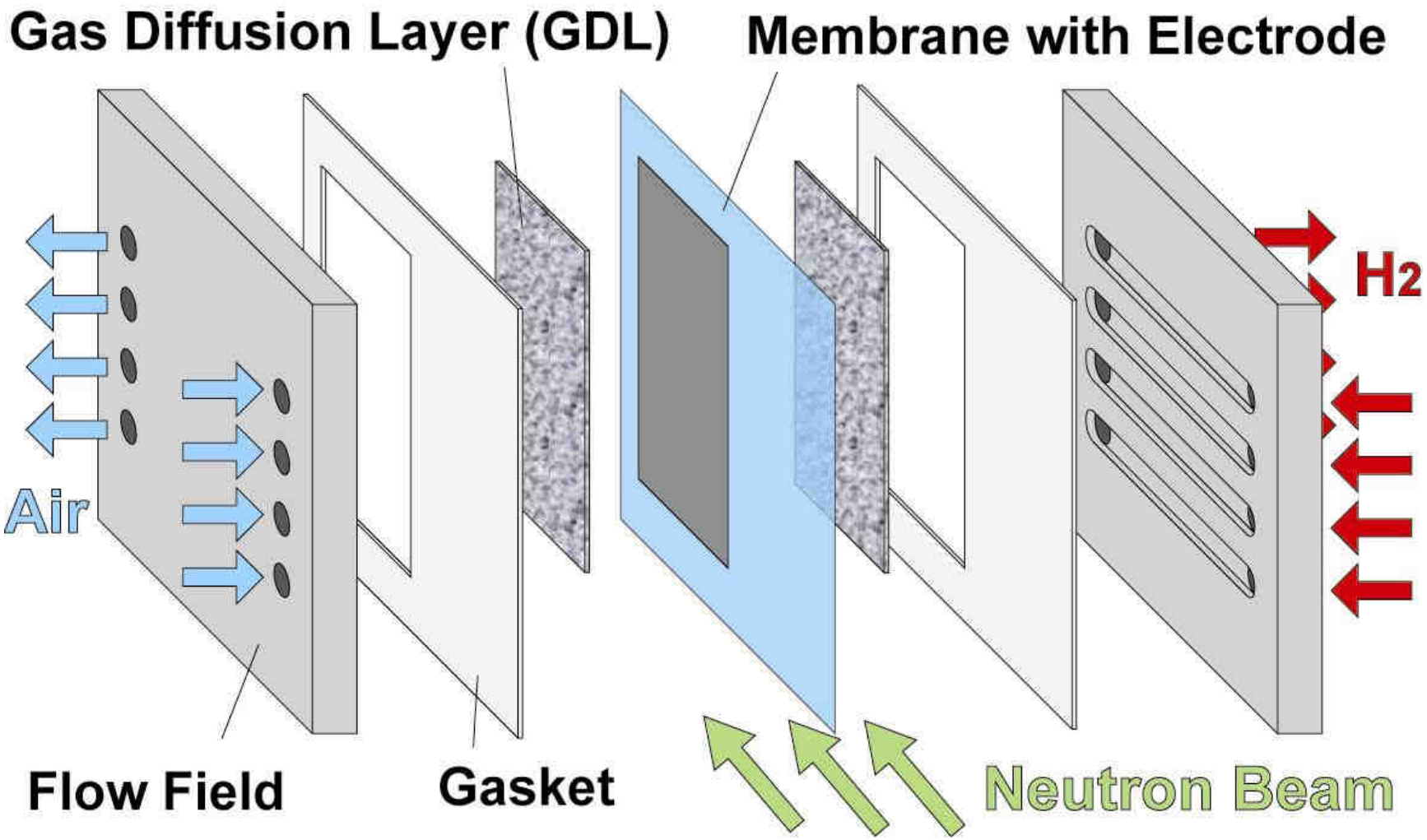
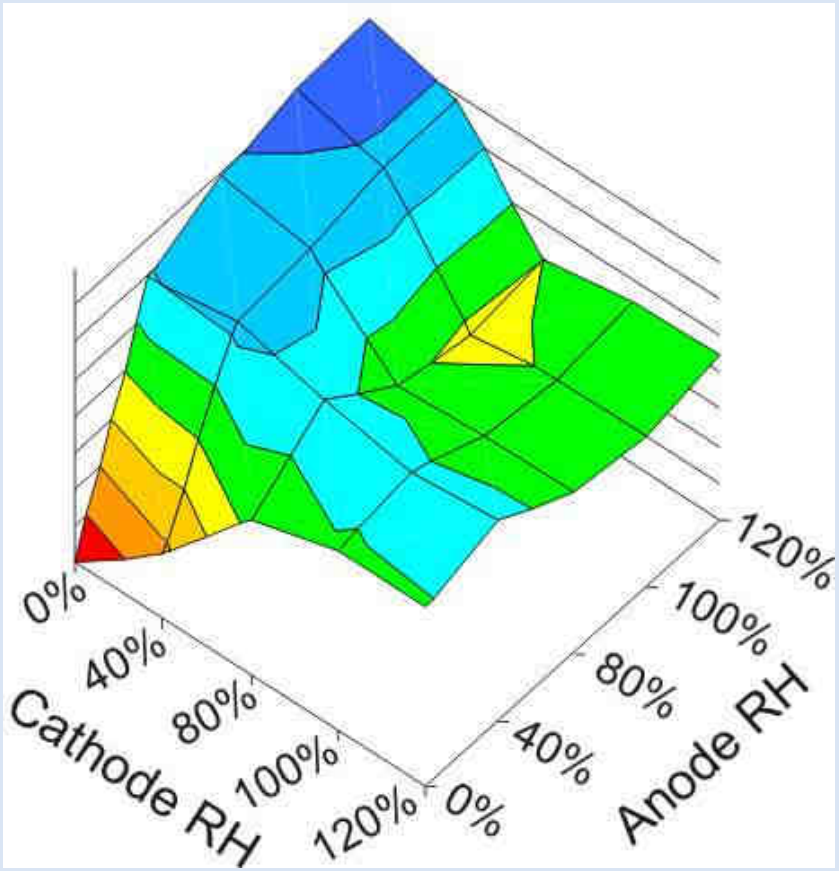
New Differential Fuel Cell

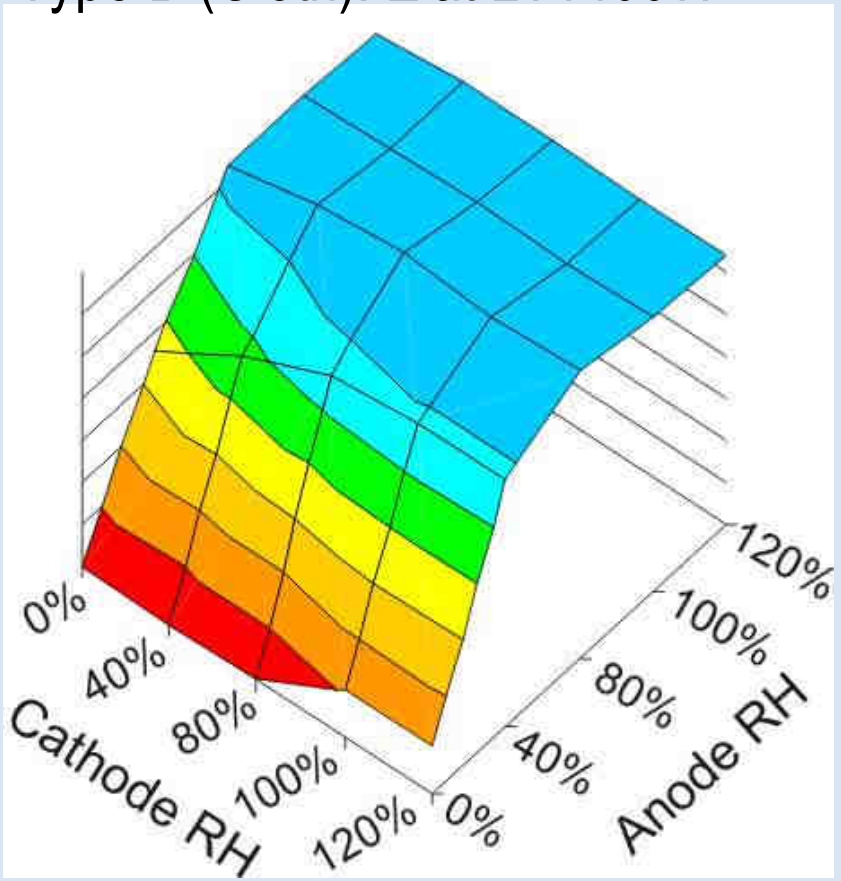


Performance vs. Relative Humidity

Type A (Paper): SGL24BC

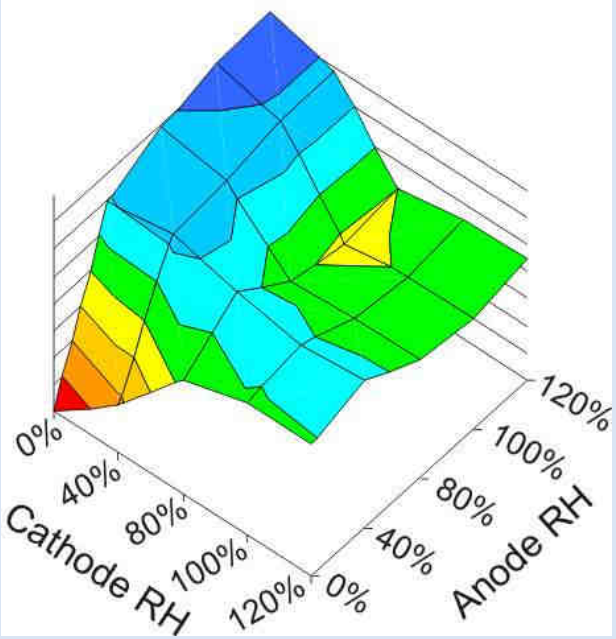


Type B (Cloth): Elat LT1400W



Water Distribution vs. R.H.

Type A (Paper)



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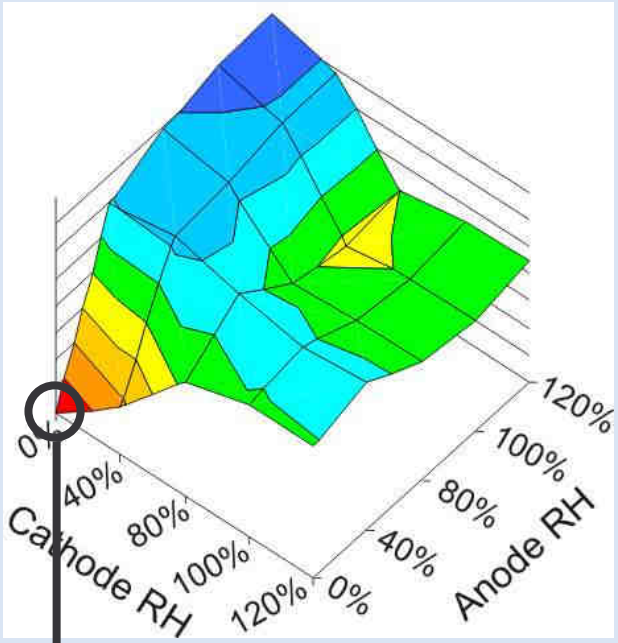
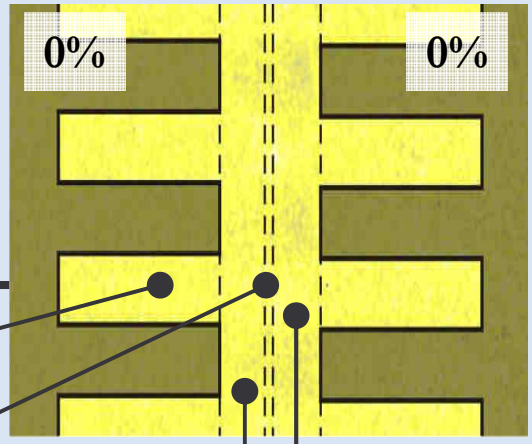




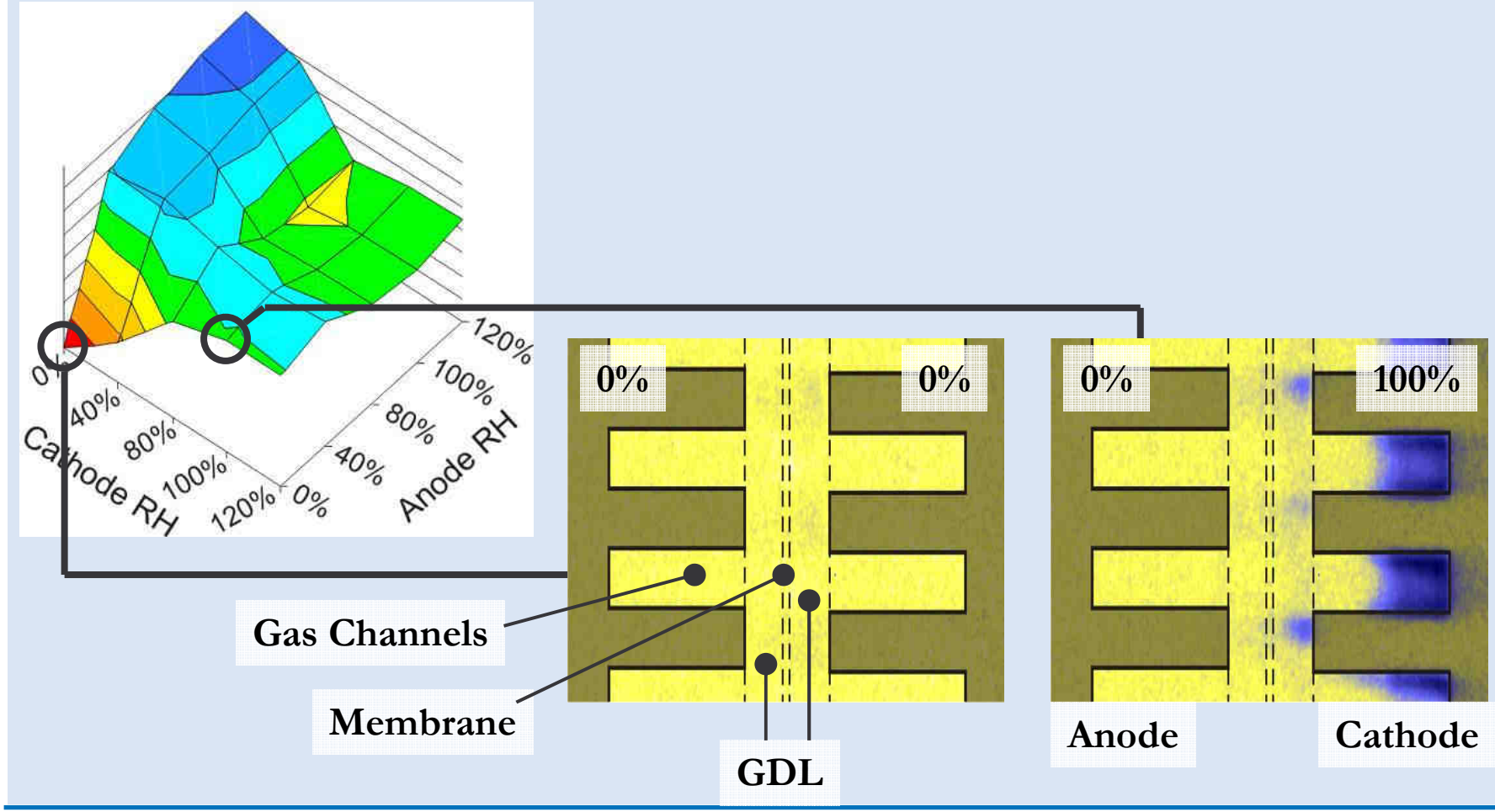
Gas Channels

Membrane

GDL

Water Distribution vs. R.H.

Type A (Paper)



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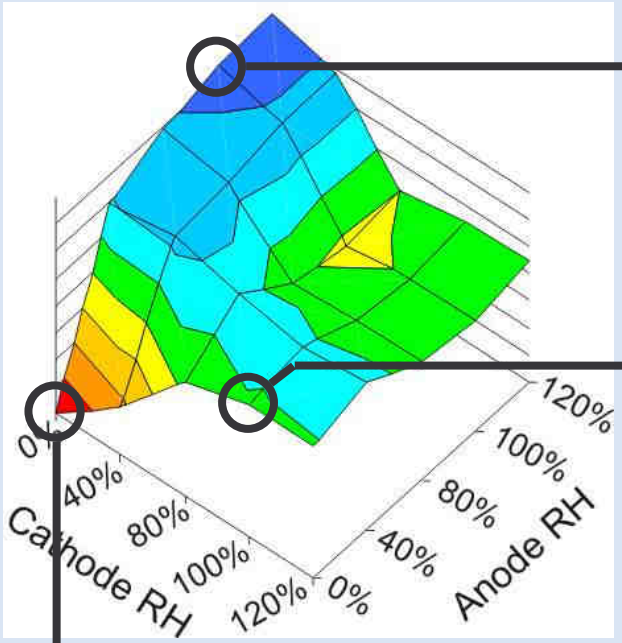
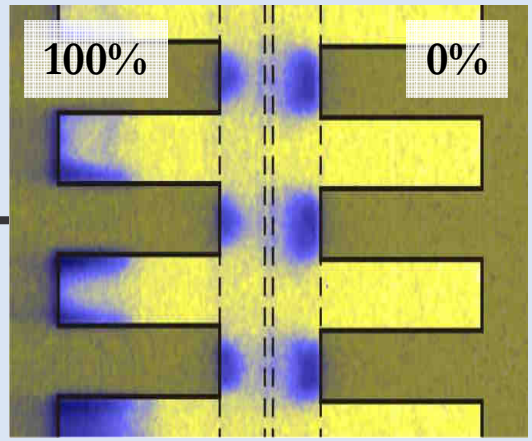
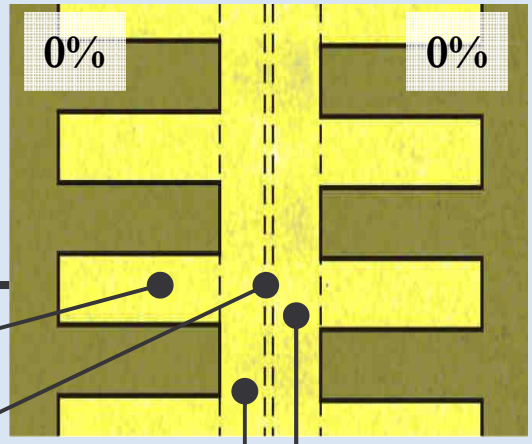
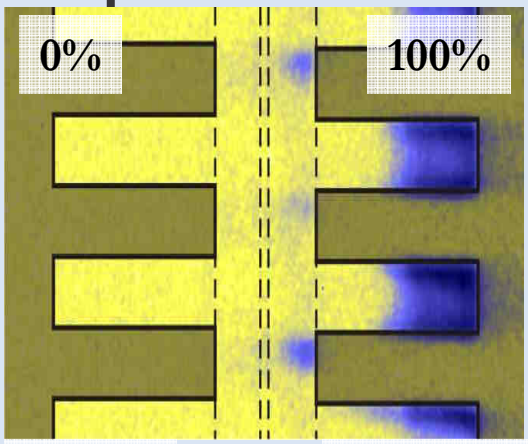








Gas Channels

Membrane

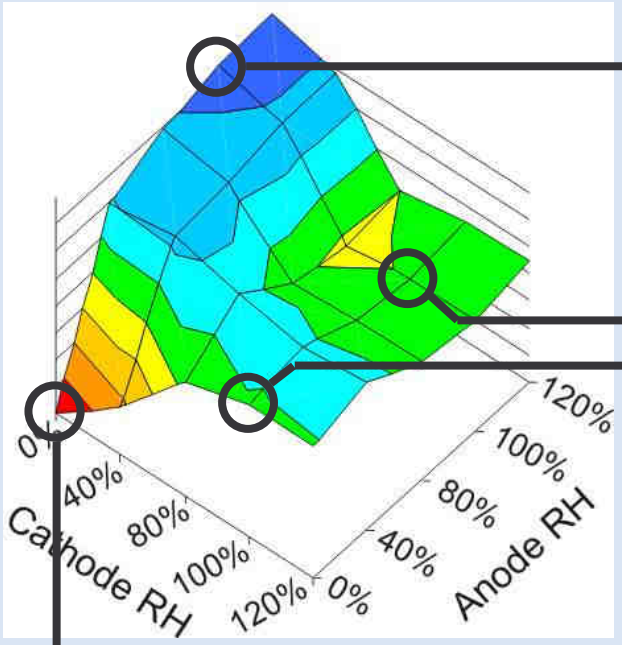
GDL

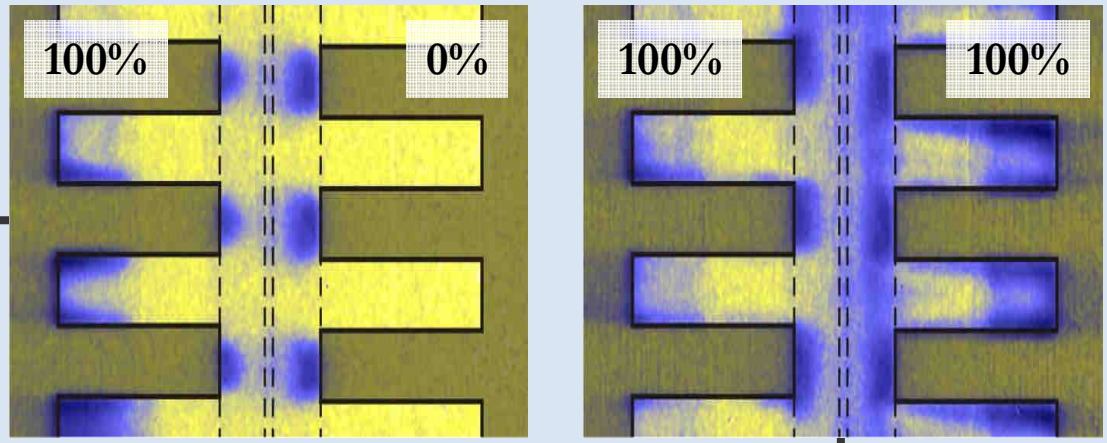
Anode

Cathode

Water Distribution vs. R.H.

Type A (Paper)





Gas Channels

Membrane

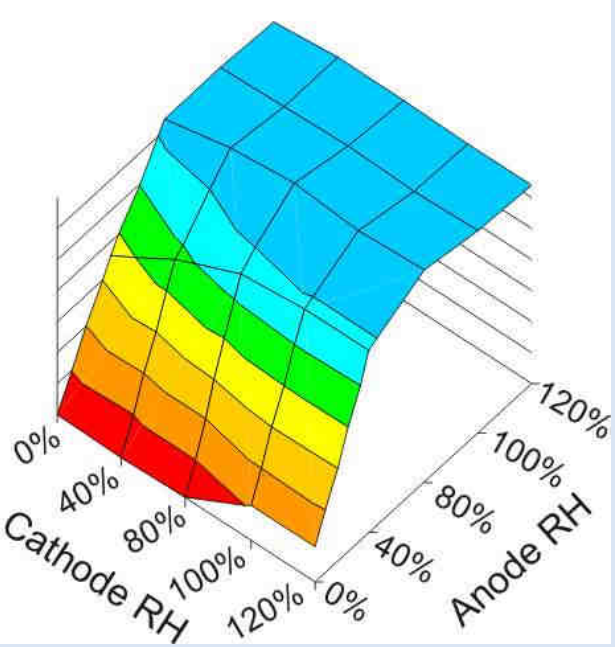
GDL

Anode

Cathode

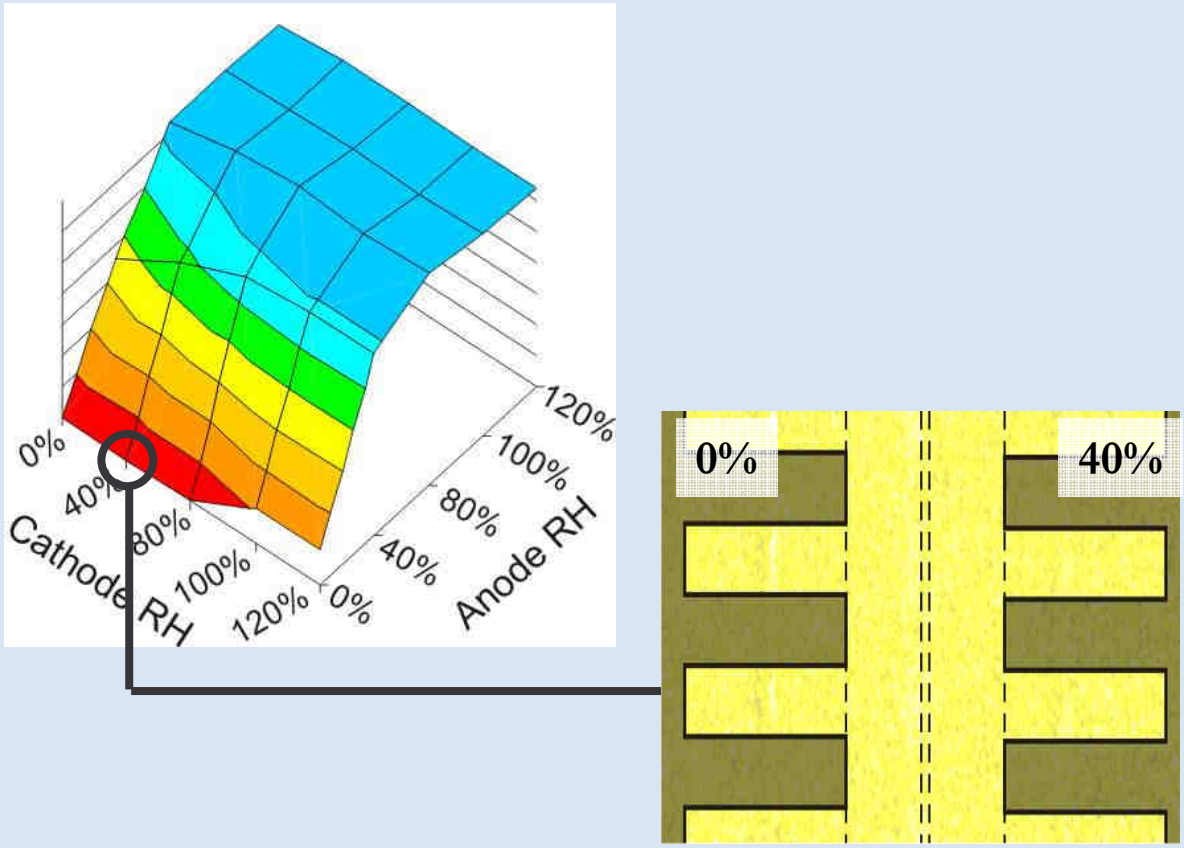
Water Distribution vs. R.H.

Type B (Cloth)



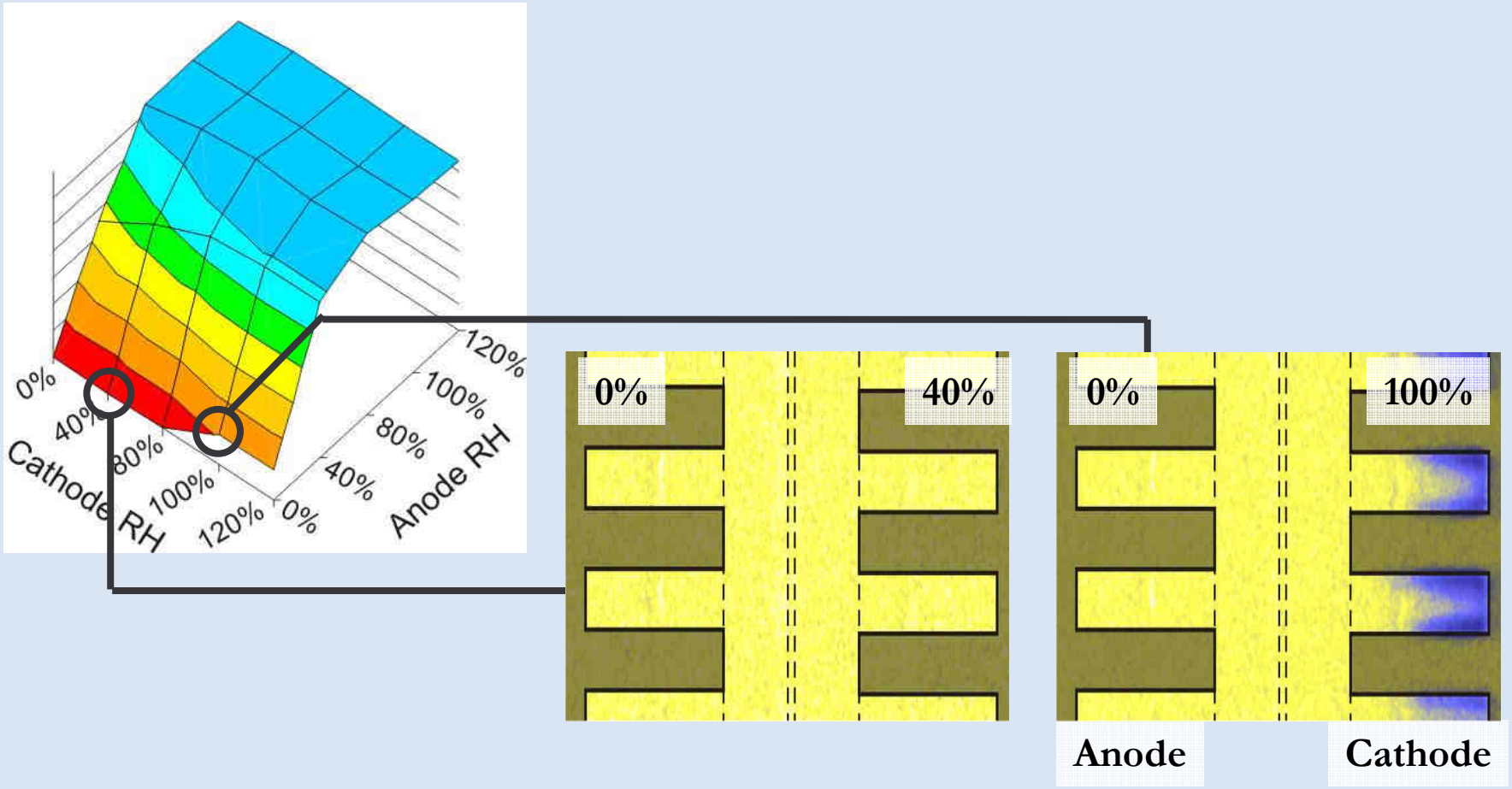
Water Distribution vs. R.H.

Type B (Cloth)



Water Distribution vs. R.H.

Type B (Cloth)



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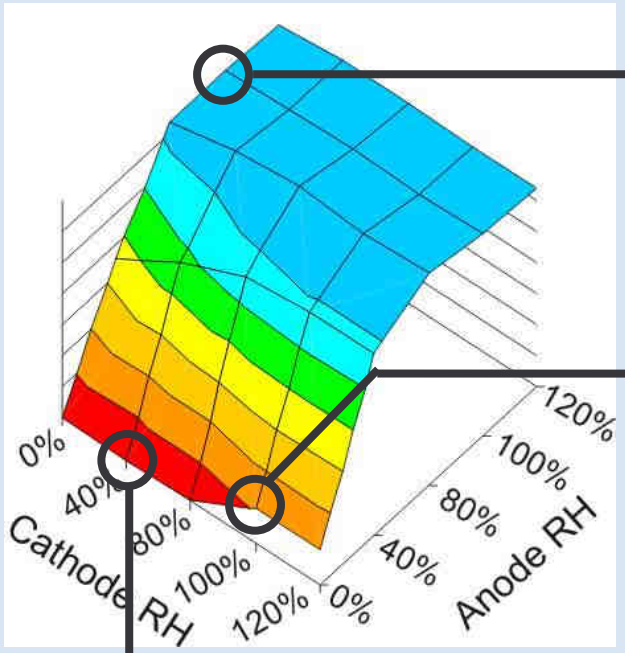
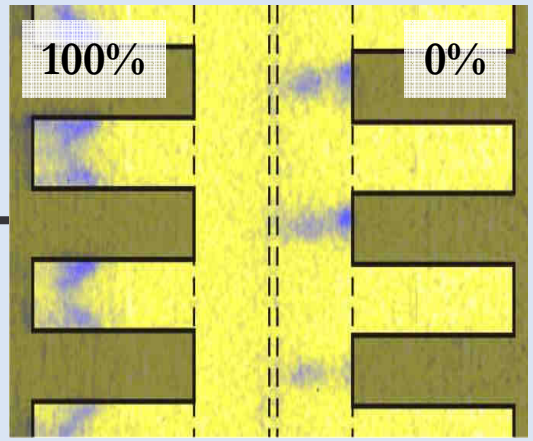
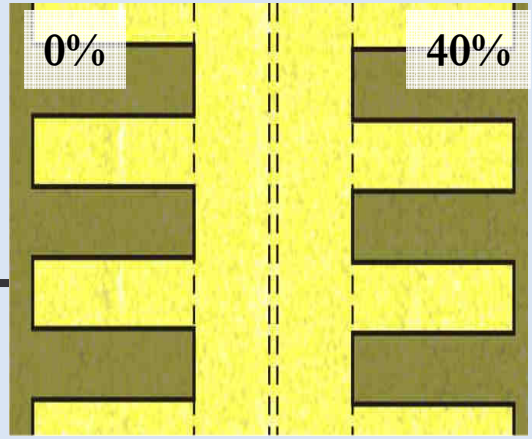
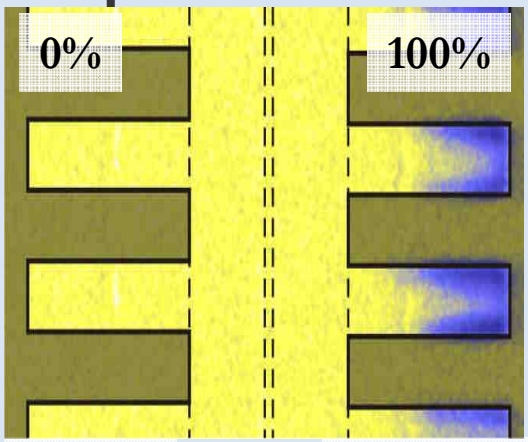




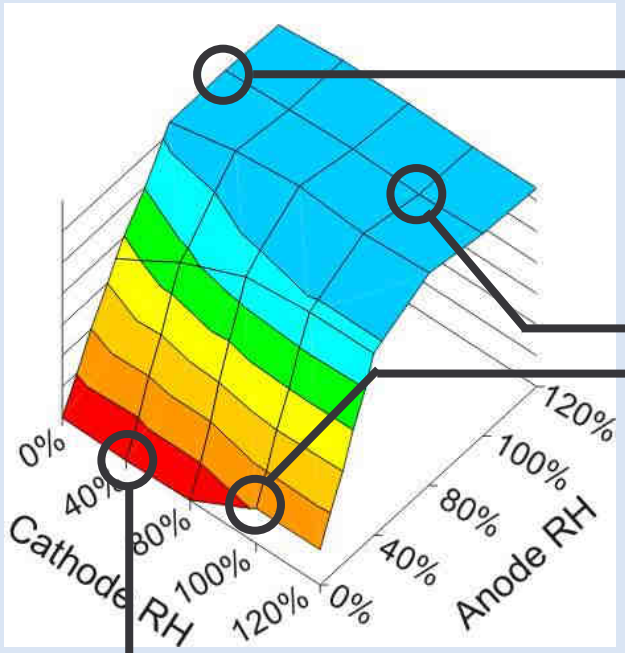


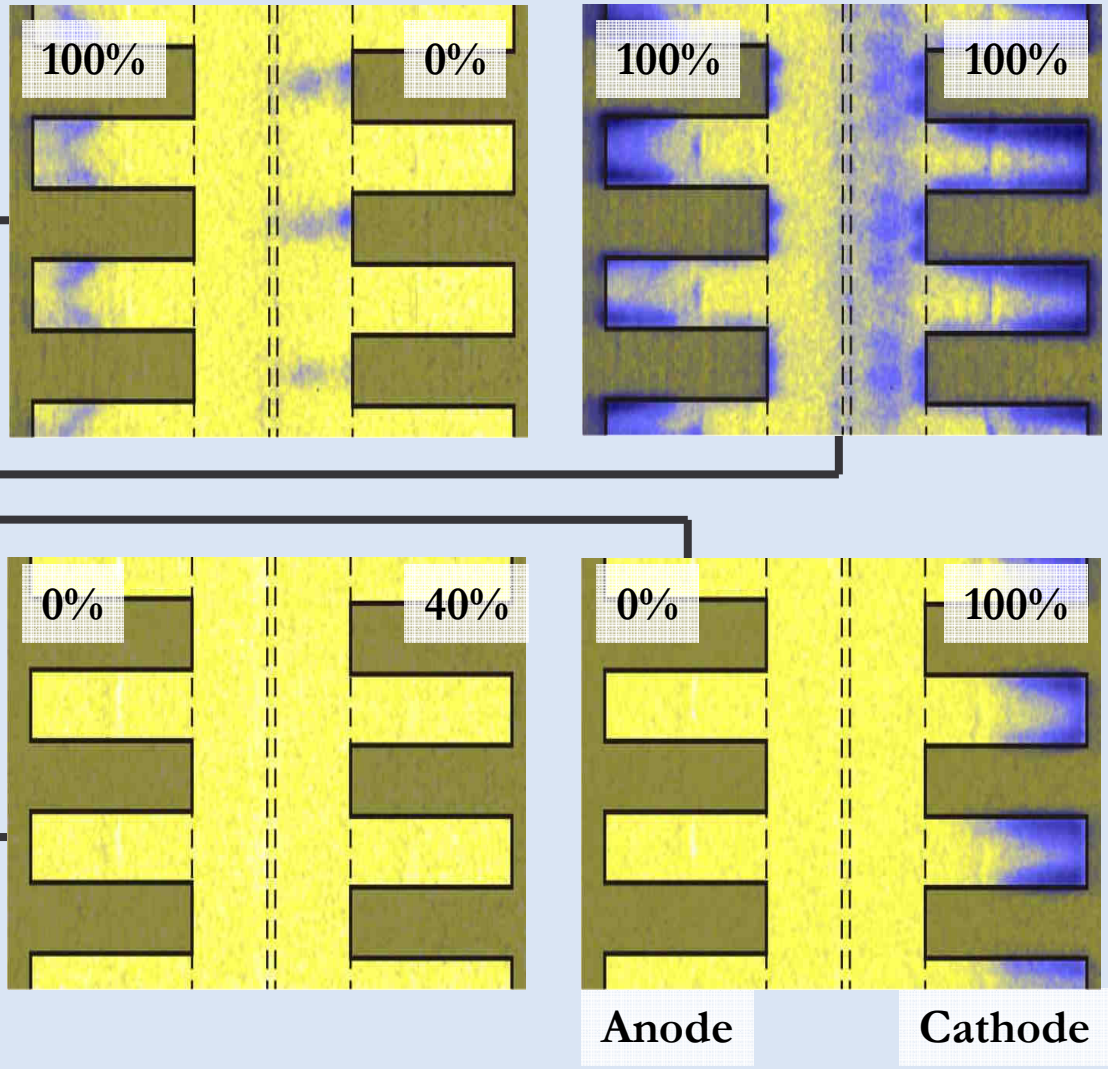


Anode Cathode

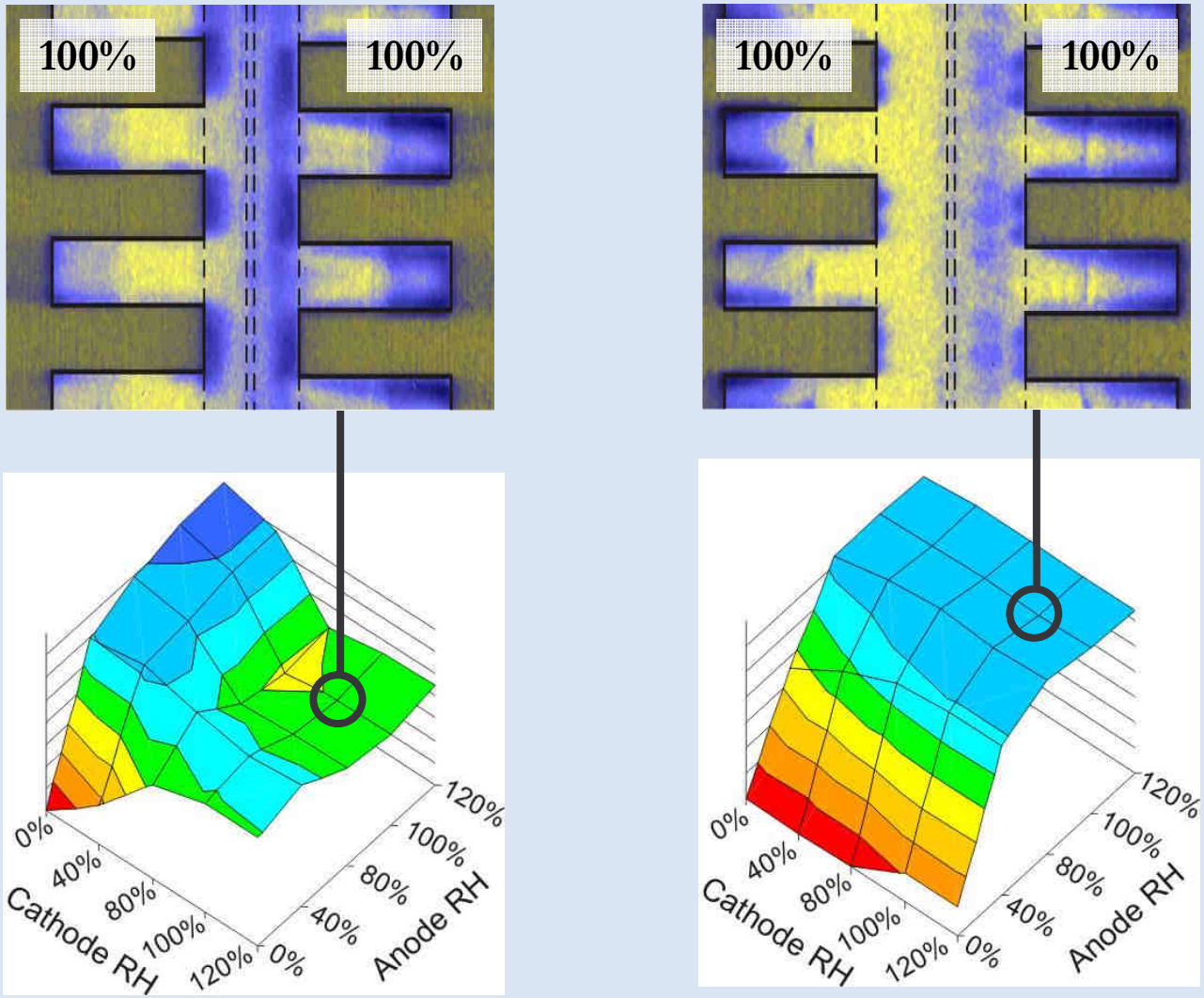
Water Distribution vs. R.H.

Type B (Cloth)

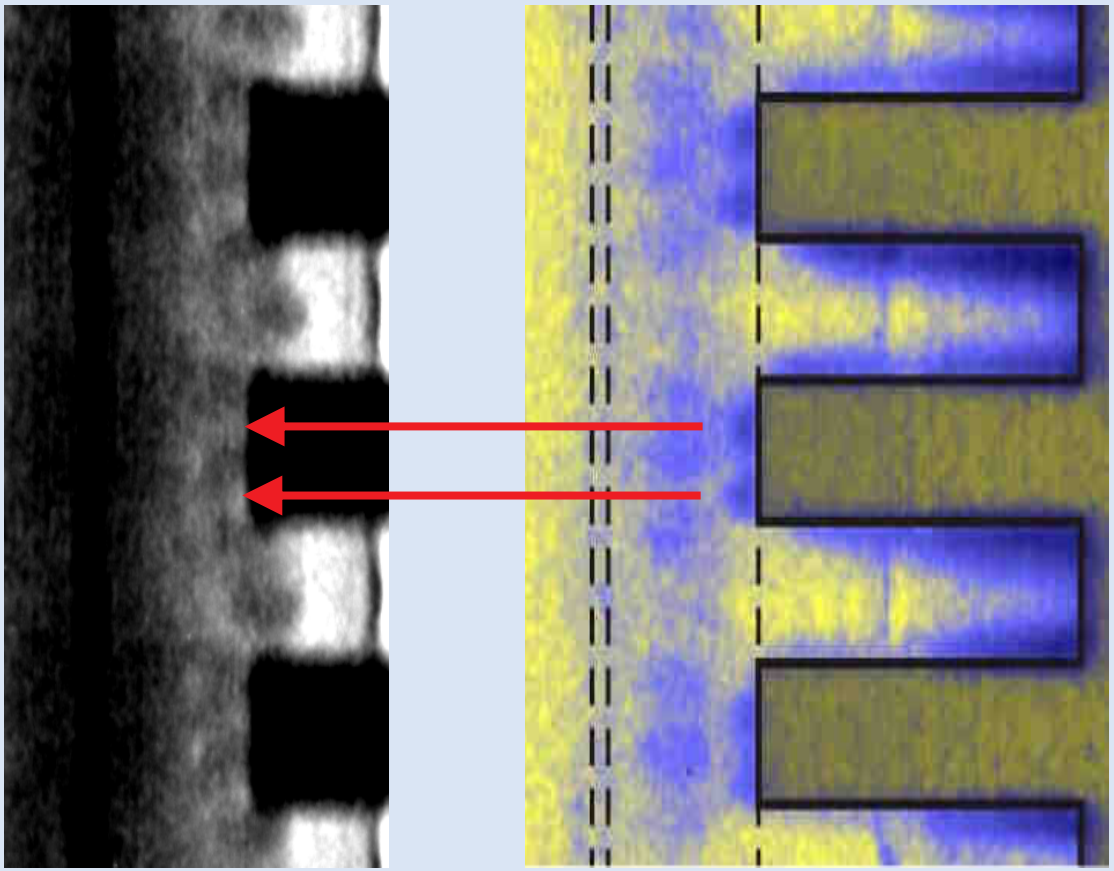




Material Comparison at 100% RH

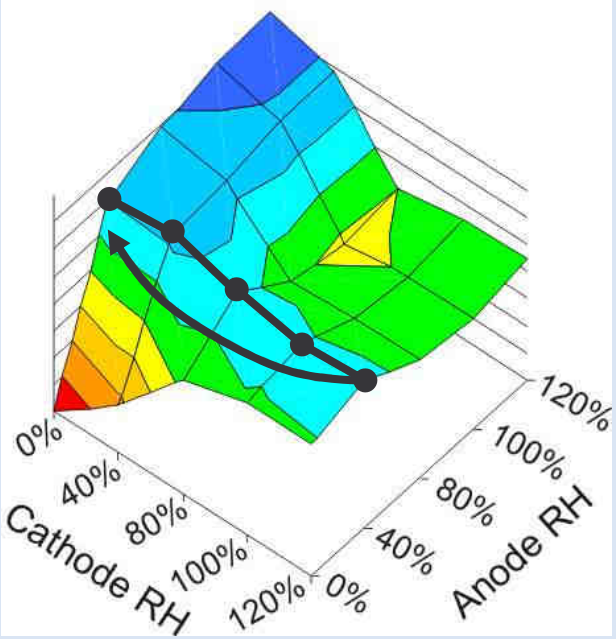


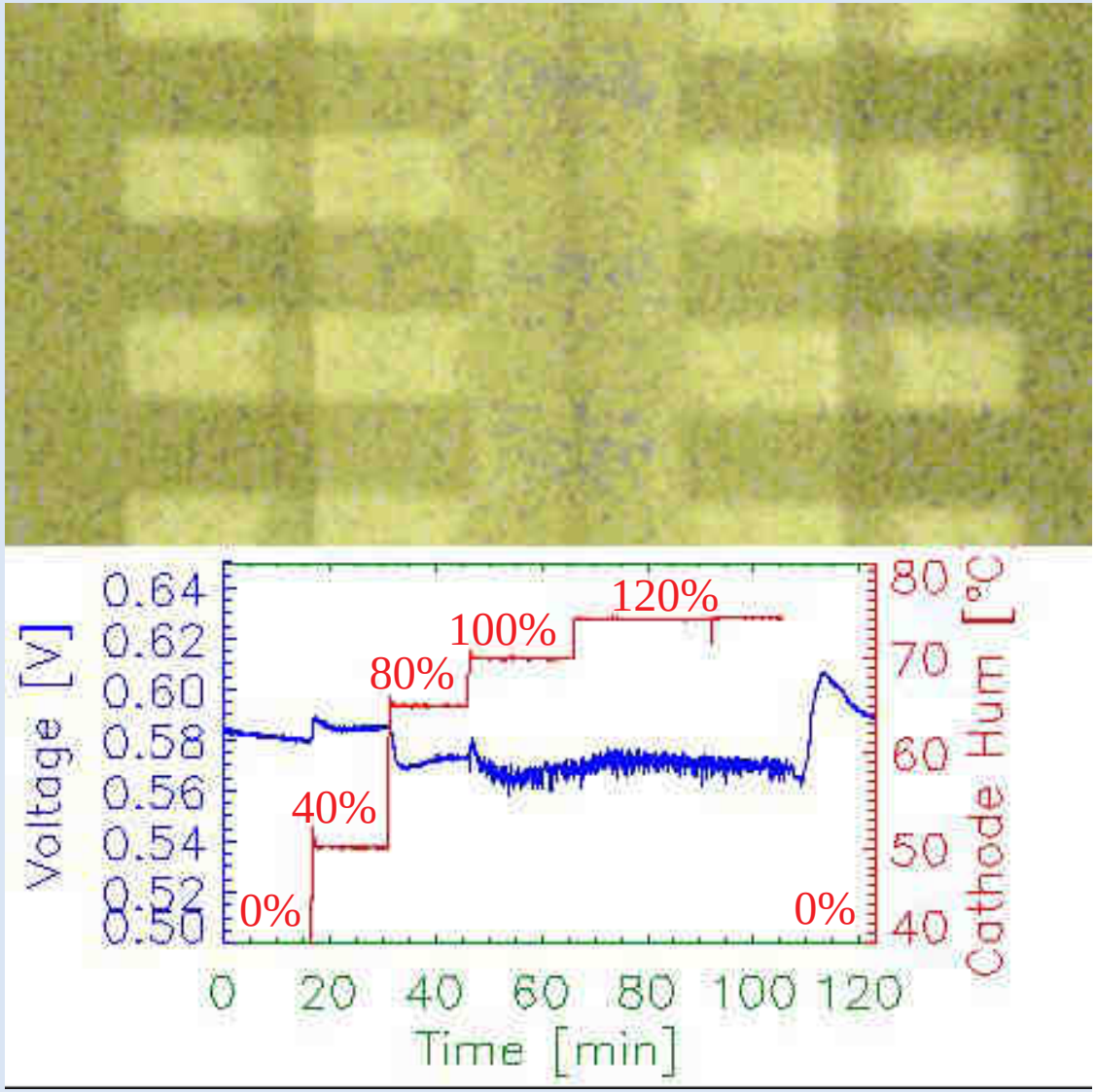
Detail of Water Distribution in Carbon Cloth



Dynamic imaging

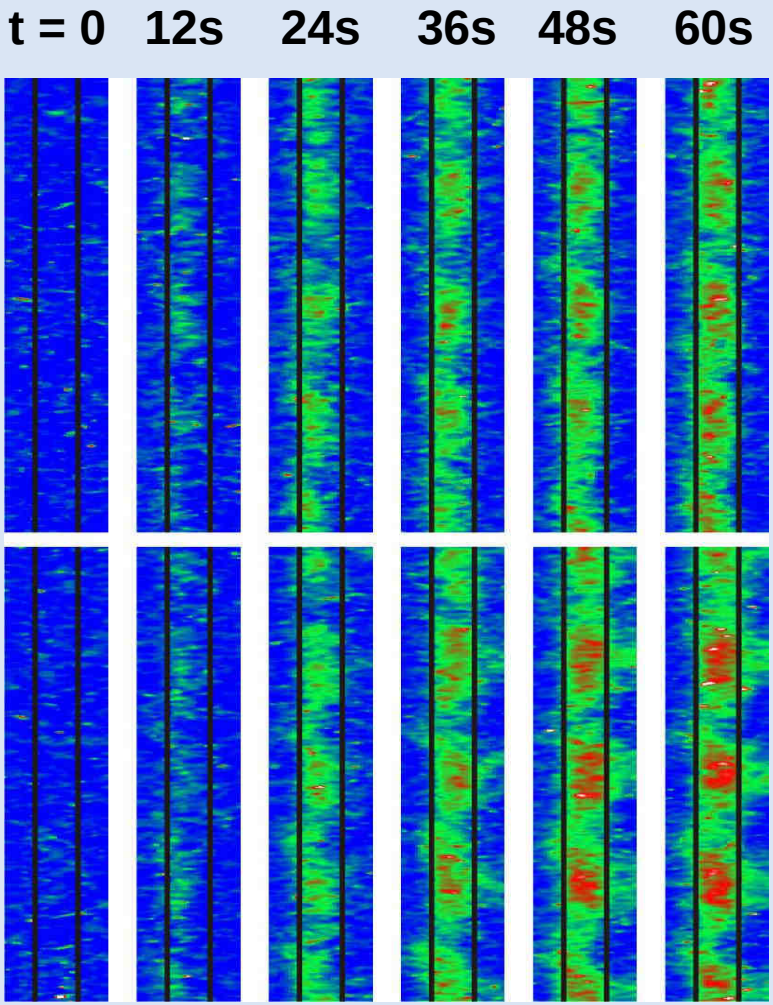
Anode RH: 40%





Labeling with ^2H – Transient Experiment

At t=0:
Change from $^1H_2$ to $^2H_2$



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Future

- Explore the spatial and temporal limits of NI
- Combine with other methods, e.g. current measurements with sub mm resolution
- Combine with ex situ characterization

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