

LATEST FINDINGS FROM THE CANADIAN-GERMAN FUEL CELL COLLABORATION

Project DEKADE: **D**eutsch-**K**anadische Brennstoffzellenkooperation: **D**iagnose und **E**ntwicklung von Komponenten für automobile Brennstoffzellen

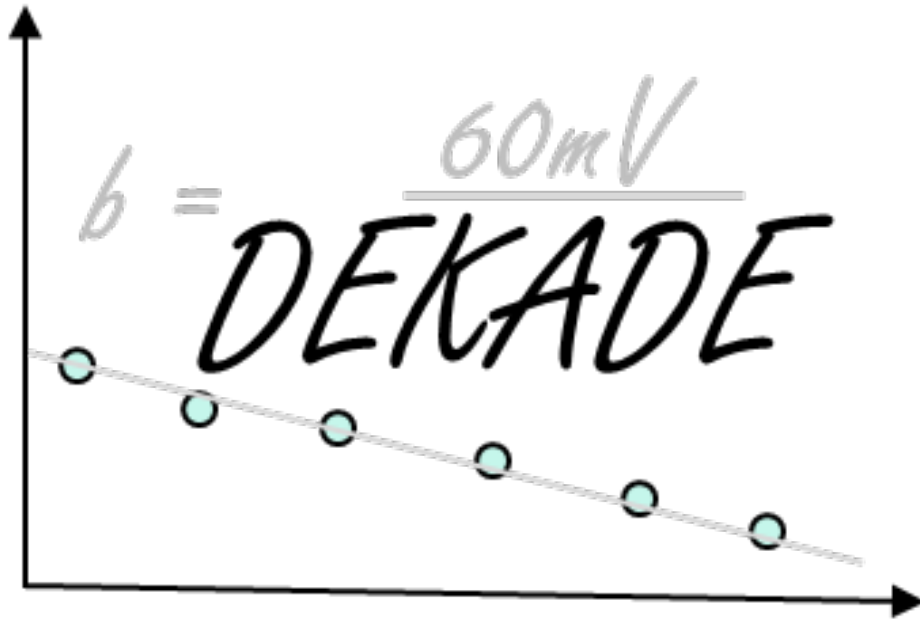
Ulf Groos

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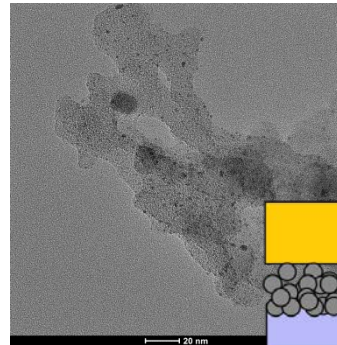
Vancouver, May 23rd 2019

www.h2-ise.com

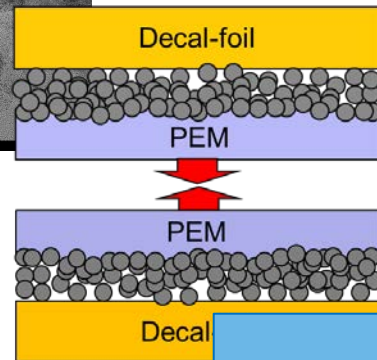
www.ise.fraunhofer.com



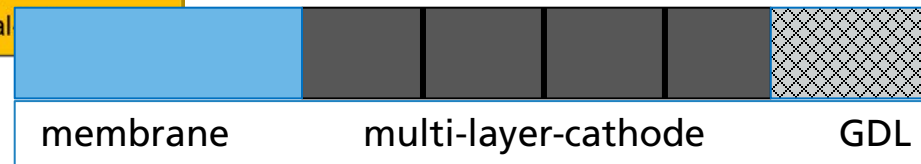
Project DEKADE: project consortium and tasks



- Carbon support
- Ex-situ analytics



- Directly deposited CCM
- Ex-situ analytics



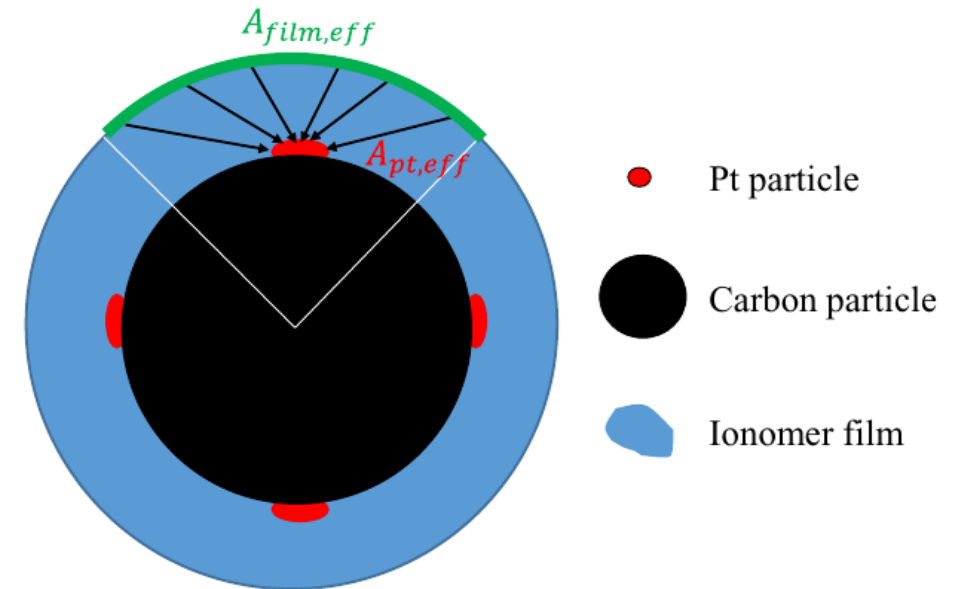
- through-plane gradients in the CCL (ionomer & Pt)



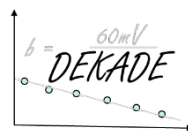
- bilayered CCMs

1D Cathode Catalyst Layer performance modelling

- modelling of electronic & protonic potential and O_2 concentration
- Representation of Ohmic resistance by experimental HFR measurements and potential boundary conditions
- Electrode geometry according to Hao et al. (2015) [1]:
 - Pt particle radius
 - Pt dispersion
 - ionomer film thickness
 - interface transport resistance

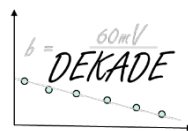
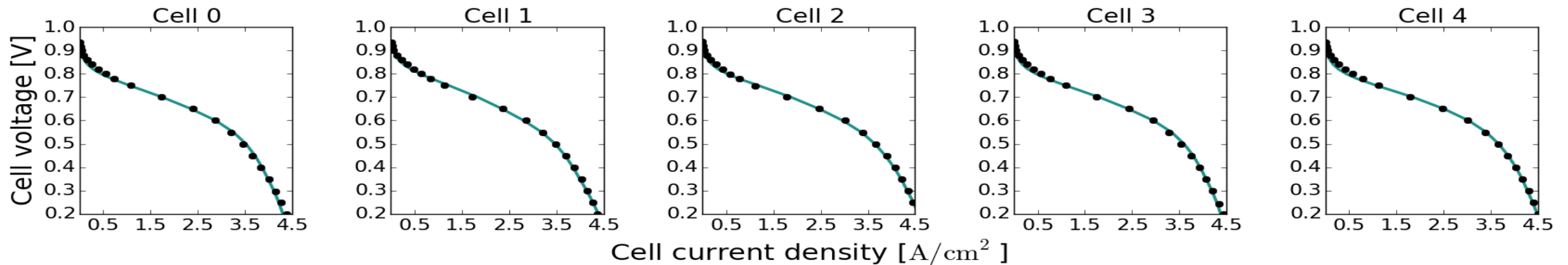


[1] Hao et al., 2015. Modeling and Experimental Validation of Pt Loading and Electrode Composition Effects in PEM Fuel Cells. Journal of the Electrochemical Society 162 (8)

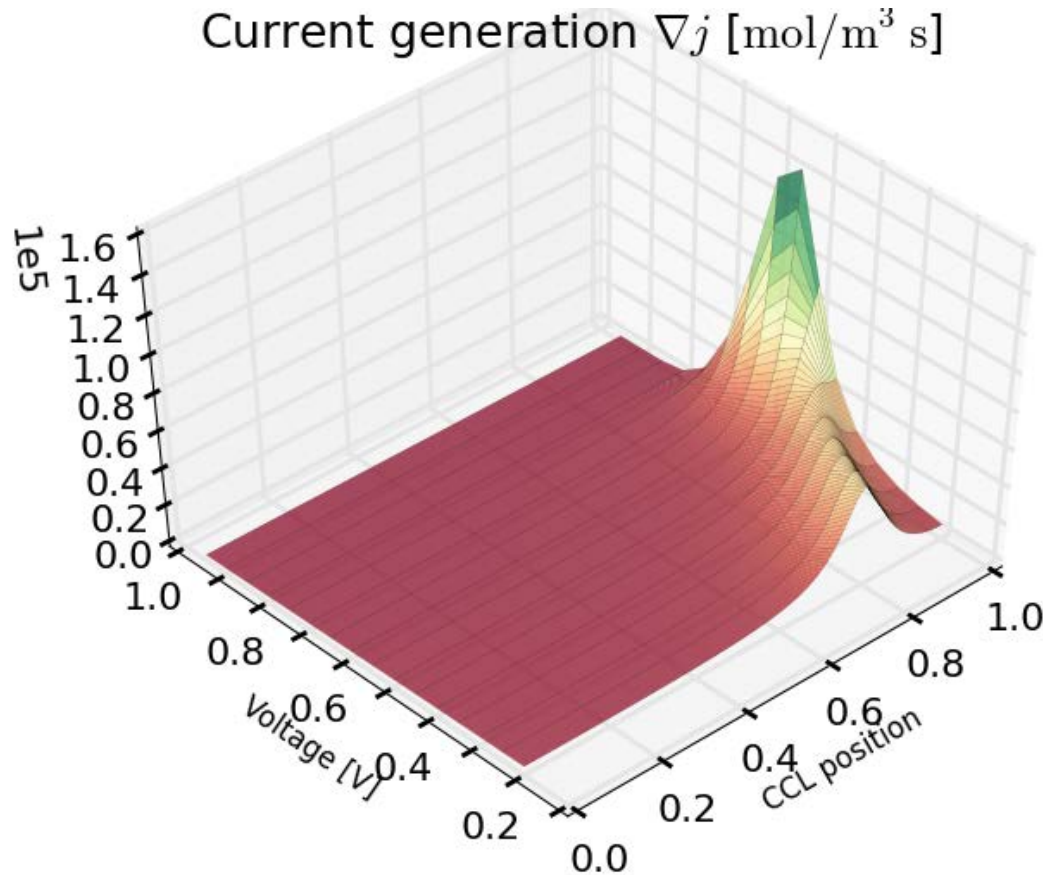


Model validation with experiments

- Experimental data: HFR, Pt loading, catalyst layer thickness
- Free fitting parameters:
 - Protonic conductivity
 - O₂ diffusion coefficient in pores of CCL
 - Ionomer film thickness
 - Exchange current density



Simulation results show maximum current generation near membrane



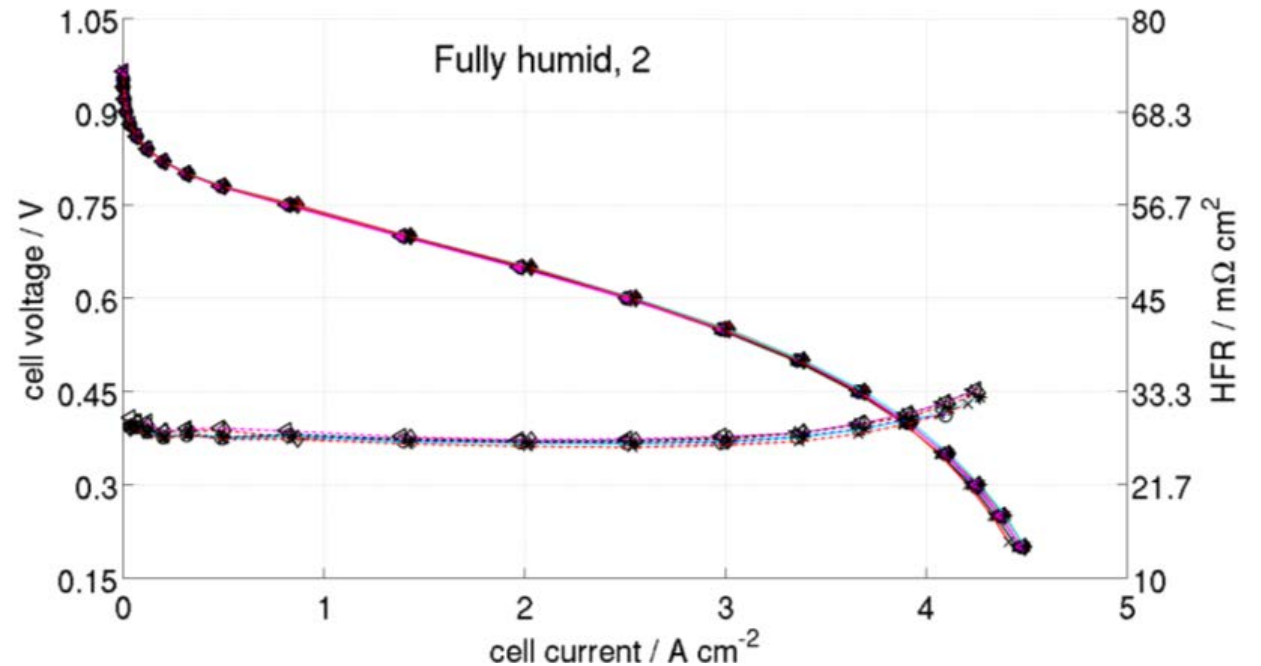
- Gradients in CCL should enhance performance
- First experiments focused on ionomer gradients to optimize gas diffusion into CCL and protonic conductivity from membrane into CCL

Fraunhofer baltic PEM fuel cell component testing

quickCONNECTfixture Liquid Cooling high amp



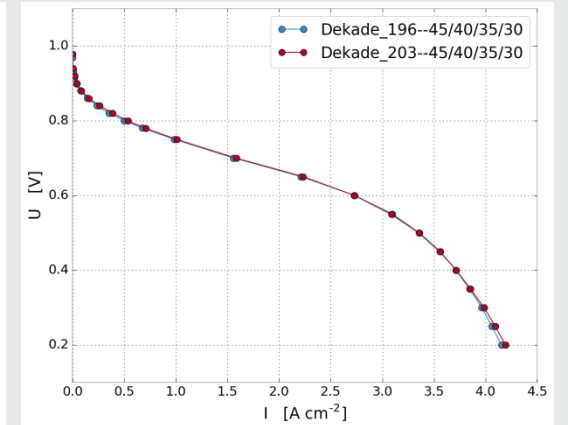
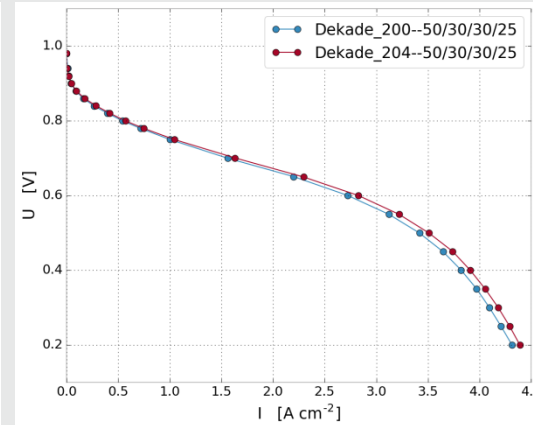
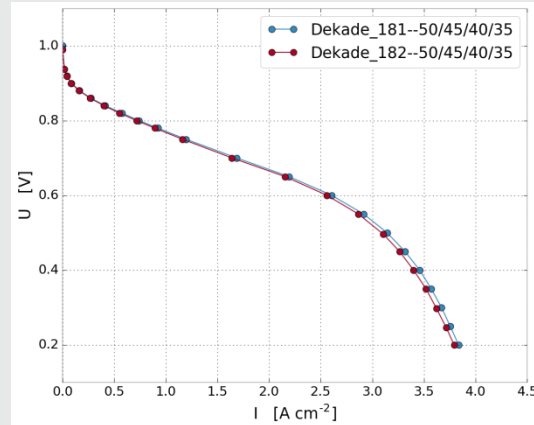
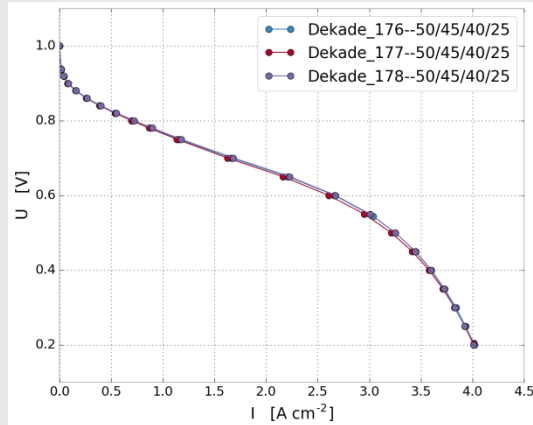
- Differential test cell
- easy handling for fast component exchange
- Liquid cooling
- Controllable (pneumatic) clamping pressure directly on the active area



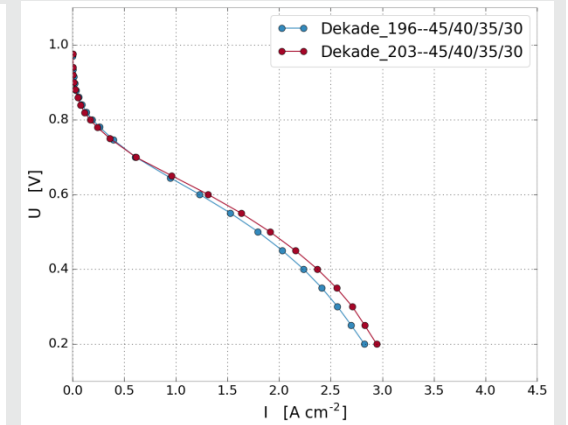
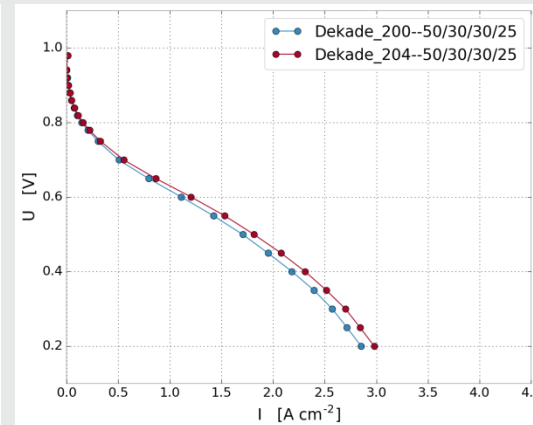
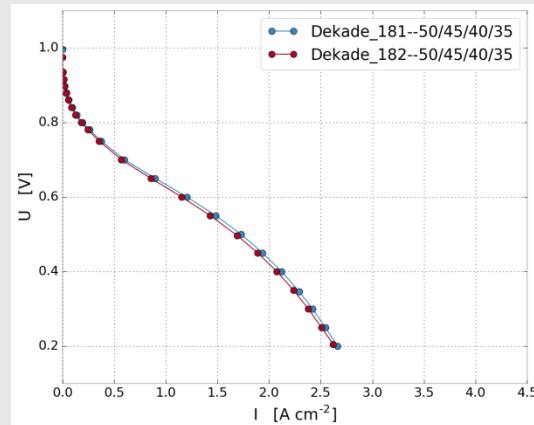
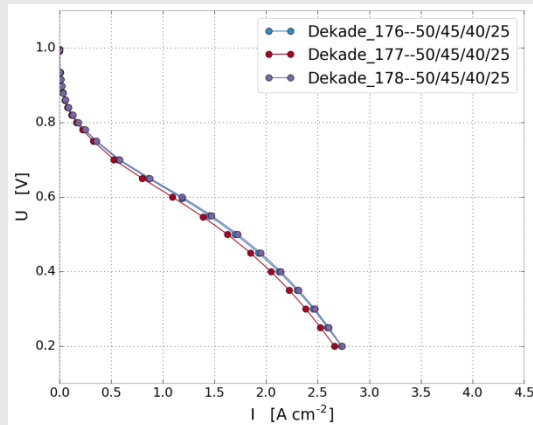
Above: Characterization of 5 samples of the same MEA.

Reasonable reproducibility in screen printing ionomer gradients into CCL

RH 100%

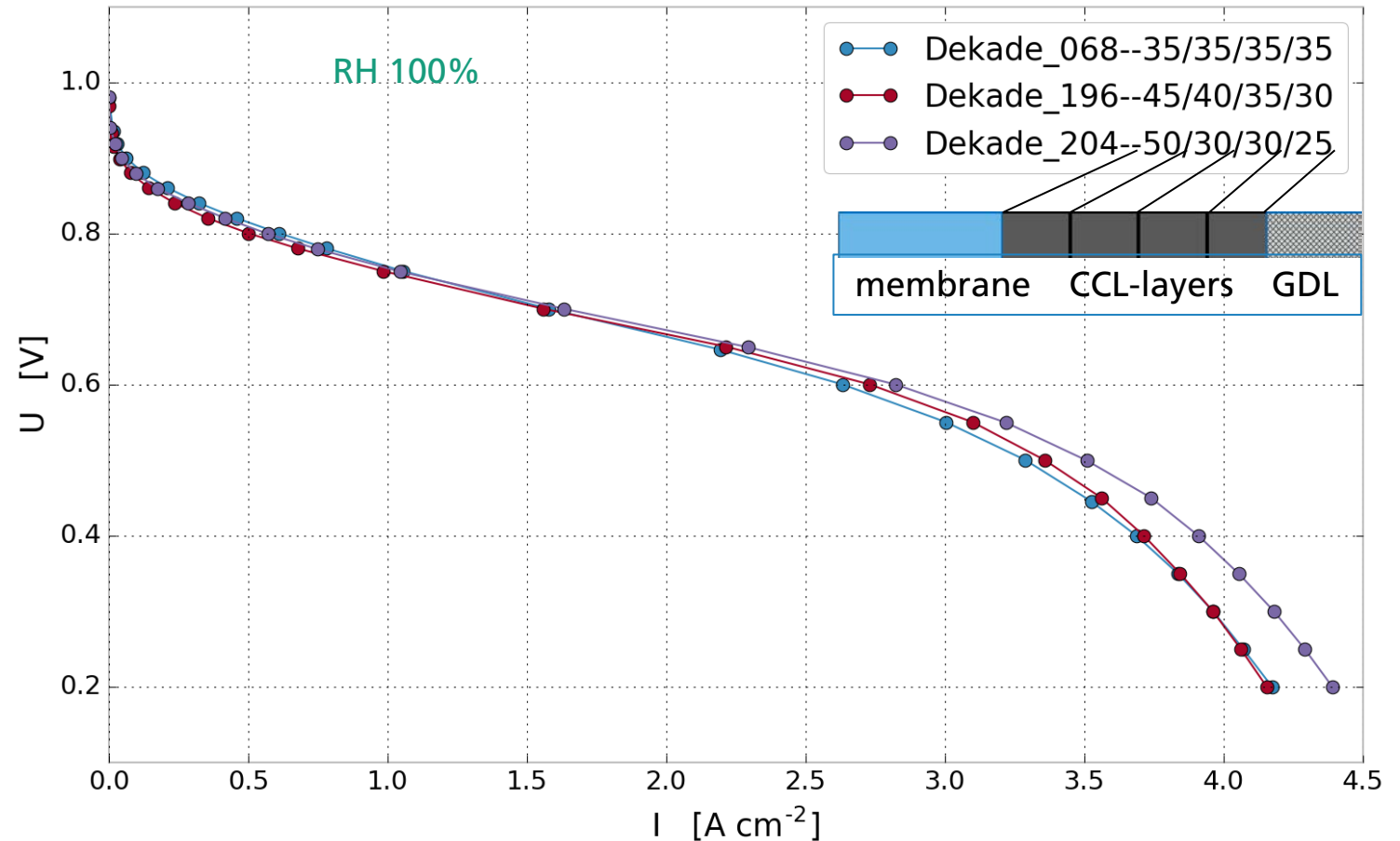


RH 40%



Experimental results with ionomer gradients in CCL (wet)

- 4 layers with different ionomer content
(total Pt loading 0,25 mg/cm²)
 - 35 / 35 / 35 / 35 – homogeneous: 35 %
 - 45 / 40 / 35 / 30 – average: 37,5 %
 - 50 / 30 / 30 / 25 – average: 33,75 %
- Steep gradient shows highest limiting current
 - Good diffusion due to low ionomer content @ GDL interface (... /25)
 - Low protonic resistance @ membrane (50/ ...)



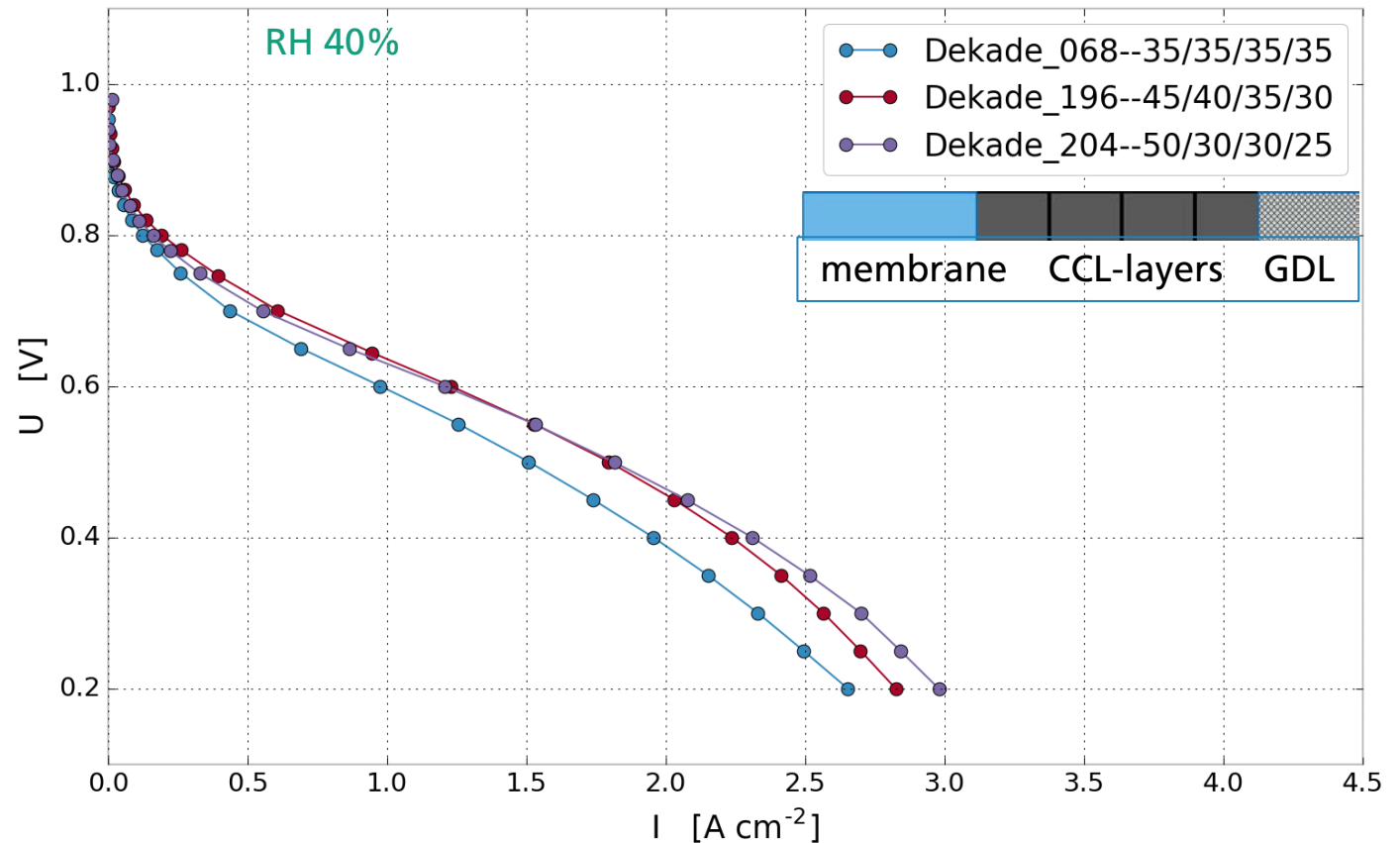
Experimental results with ionomer gradients in CCL (dry)

- 4 layers with different ionomer content (each layer with Pt loading 0,25 mg/cm²)

- 35 / 35 / 35 / 35 – homogeneous: 35 %
- 45 / 40 / 35 / 30 – average: 37,5 %
- 50 / 30 / 30 / 25 – average: 33,75 %

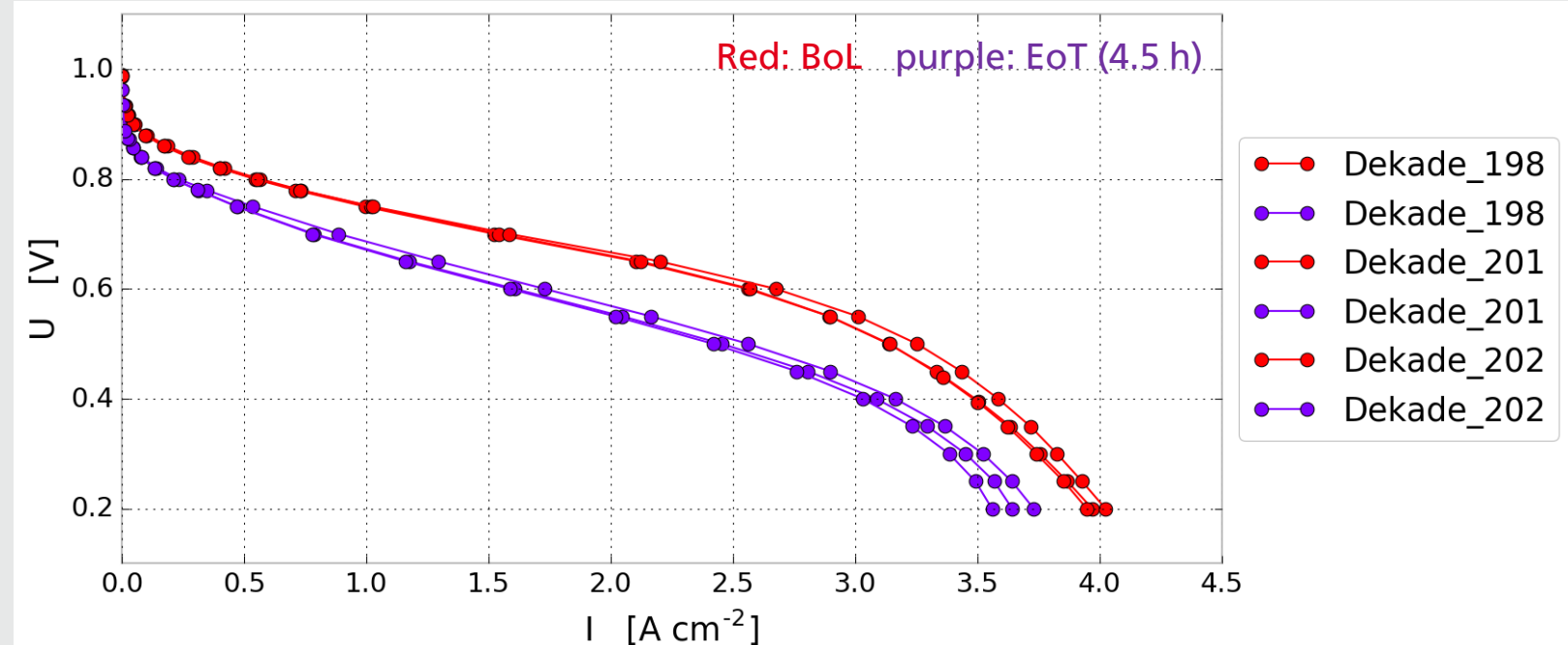
- Homogeneous gradient with significant performance reduction @ dry conditions

- Proton resistance at CCL-membrane interface dominates performance



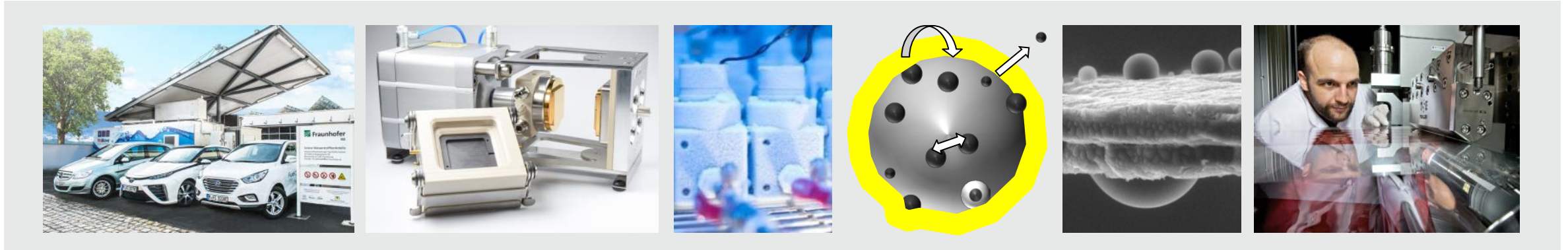
Outlook

- Microscopy of CCLs w & w/o gradients
- CCL with Pt gradients
- Investigation of degradation behaviour
- Investigation of break-in procedures



First results with new AST protocol (combined catalyst and support ASTs).

Thank you very much for your attention!



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