Self-supporting Microporous Layers (MPLs) for PEM fuel cells

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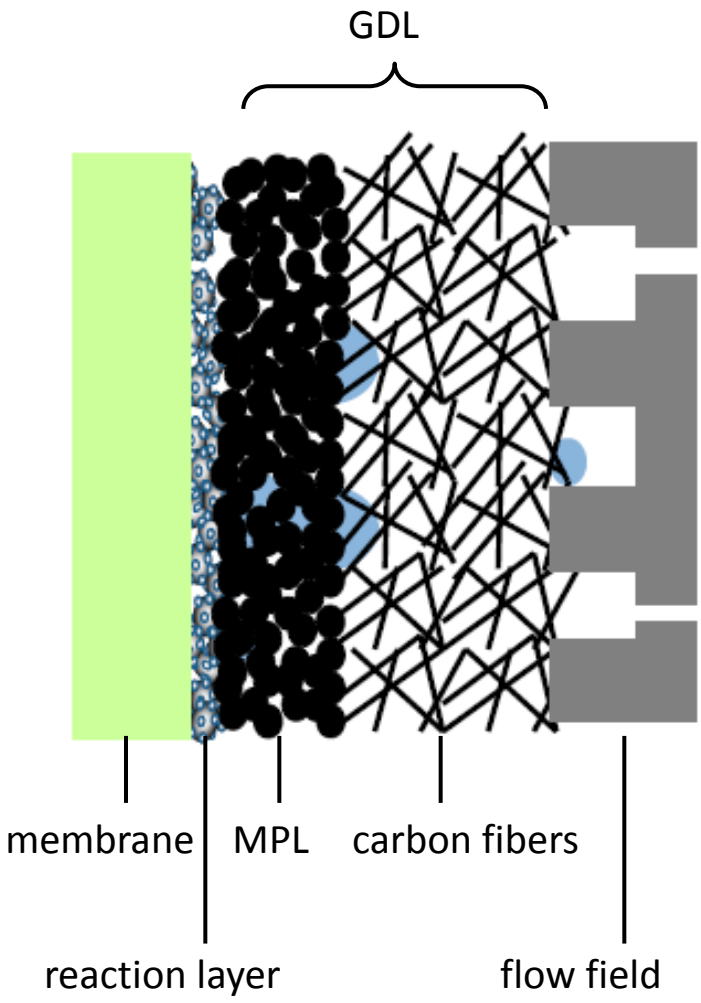
DLR

Introduction:



Main requirements of GDL:

- Provision of gas and water transport
- Significant electrical and thermal conductivity
- Mechanical support of CCM

Objective:

- Investigation of the influence of the MPL on PEM fuel cell performance
- Approach: Development of self-supporting MPL
- Advantage: Manufacturing and following treatments of the MPL are independent from the GDL substrate

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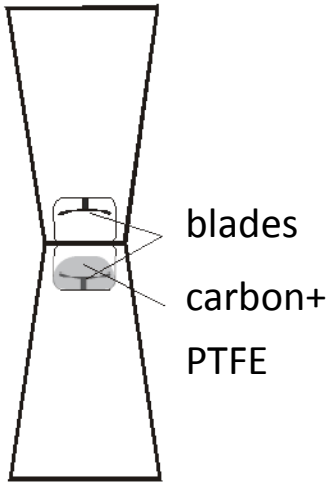
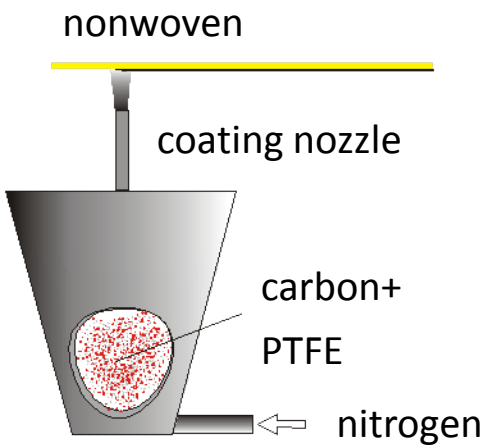
Dry spraying technology:

1. mixing

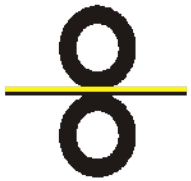


2. coating

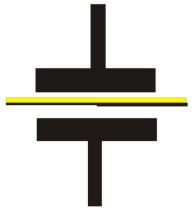


3. fixation

rolling



pressing



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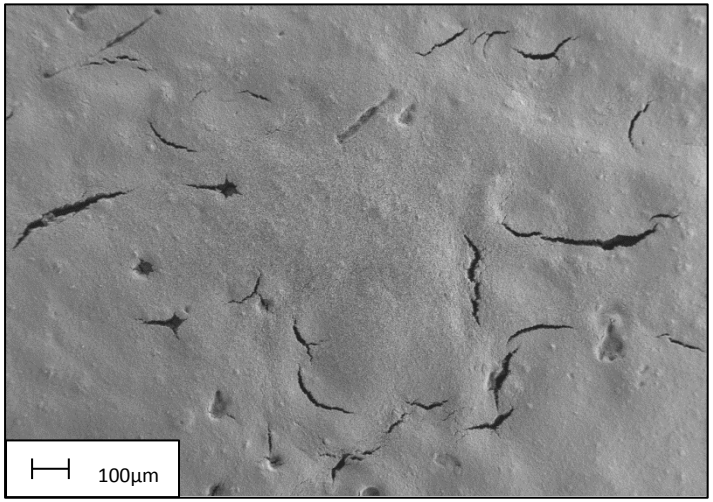
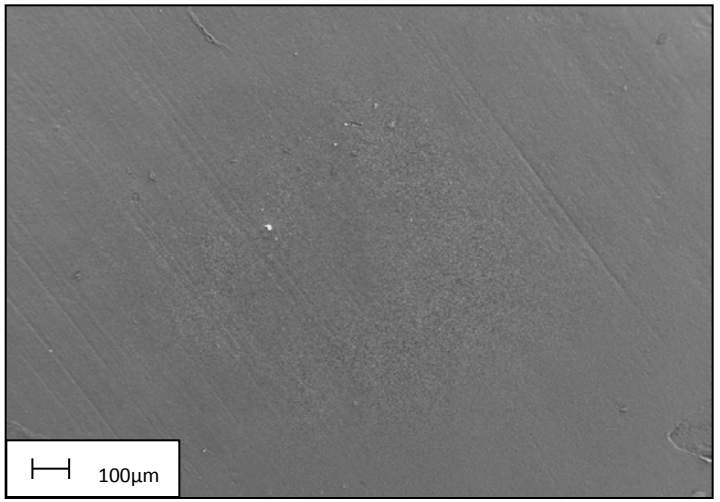
GDL assembly:

GDL25BC

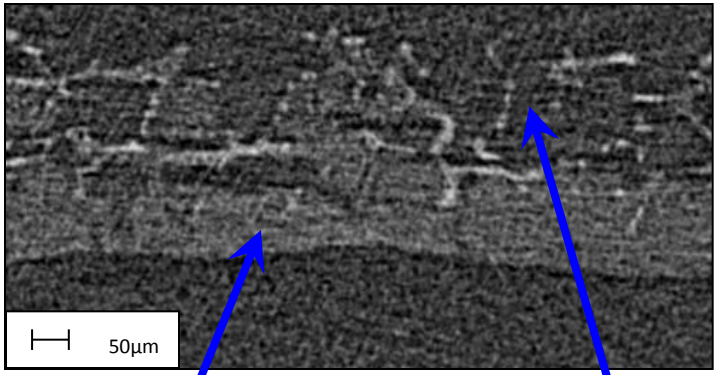
In-house GDL

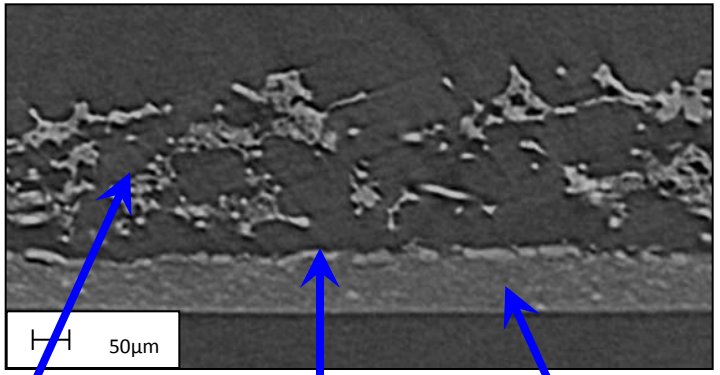
SEM:





CT:





MPL

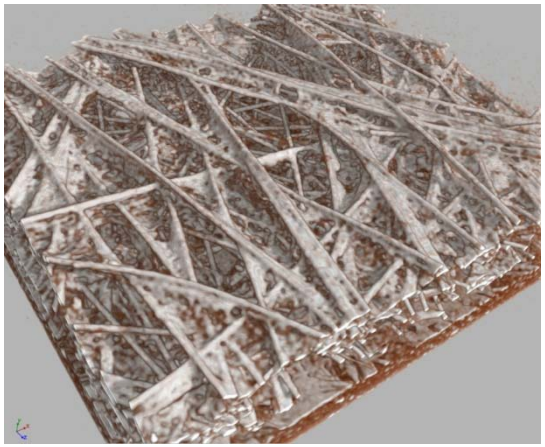
carbon fibers (GDL25BA)

nonwoven

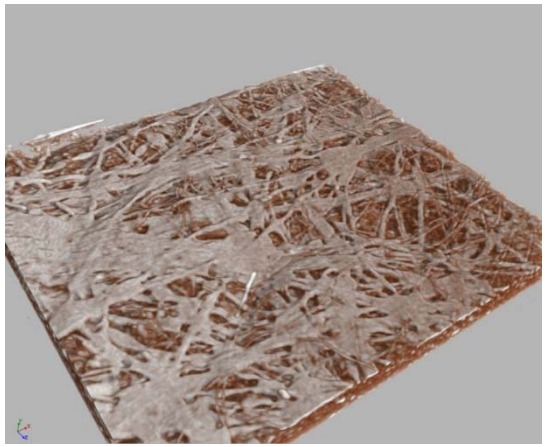
MPL

GDL assembly:

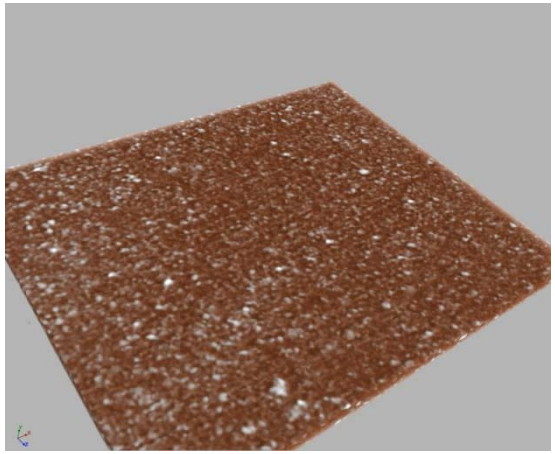
3D micrograph visualization of in-house GDL



macro porous carbon fiber substrate



nonwoven of synthetics



mixture of carbon and PTFE

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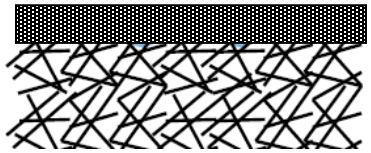
Variation in composition:

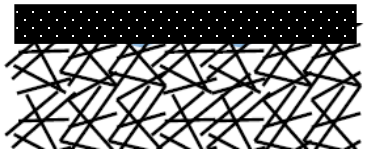
Sigracet GDL25BC

Sigracet GDL25BA

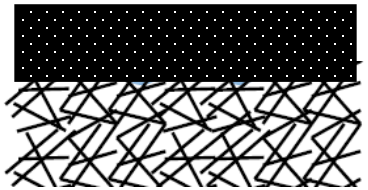
40% PTFE



20% PTFE



20% PTFE



Commercial GDLs		In-house GDLs		
25BC	25BA	P40	P20	P20D

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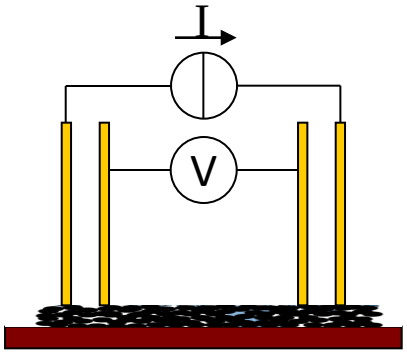
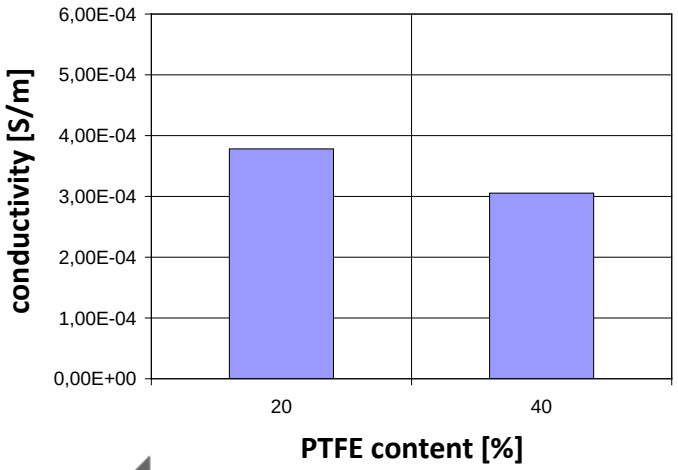
Characteristics of C/PTFE mixture:

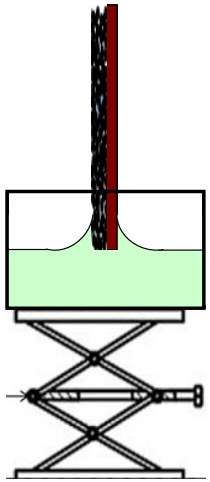
Electrical conductivity (in-plane)



4-point measurement

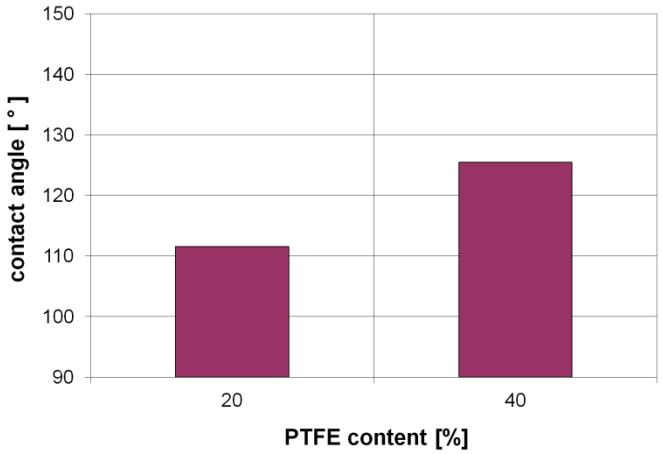


Hydrophobicity



Washburn method

Calculation of water contact angle according to Owens-Wendt



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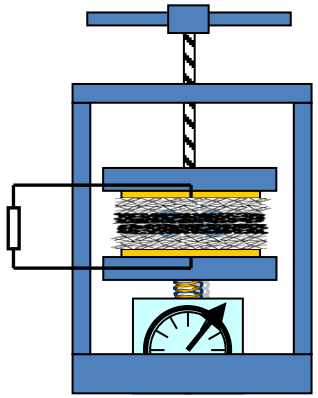
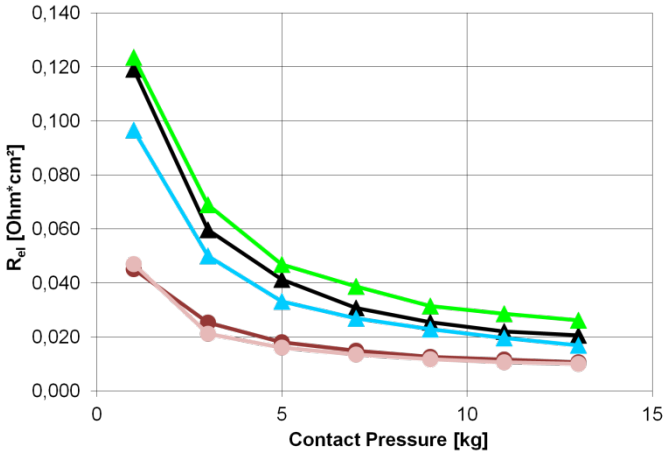
Characteristics of GDLs:

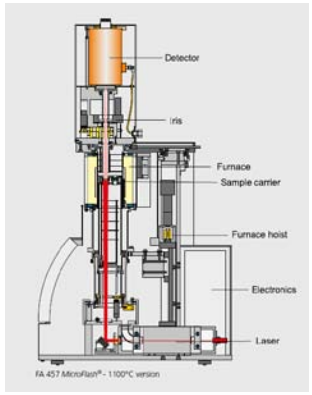
Electrical conductivity (through-plane)



2-point measurement

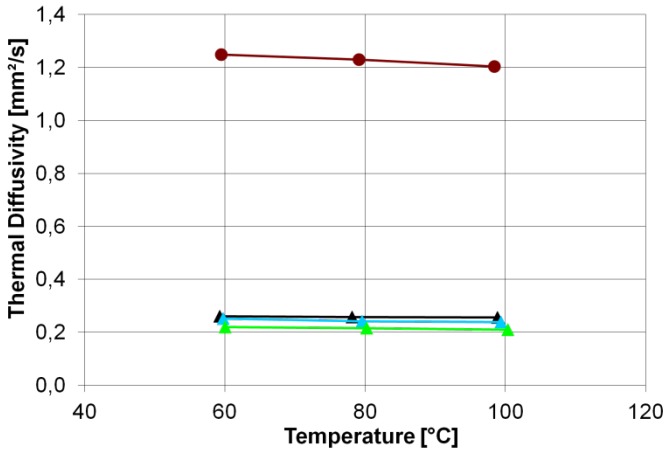


Thermal Diffusivity



Laser Flash Apparatus

LFA 457 MicroFlash® from Netzsch



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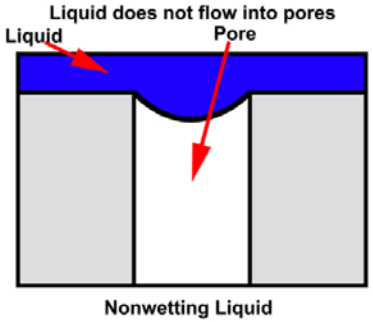
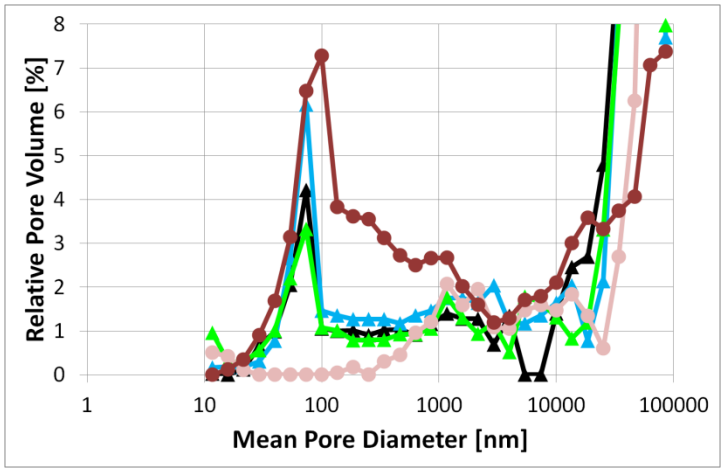
25BC	25BA	P40	P20	P20D

Characteristics of GDLs:

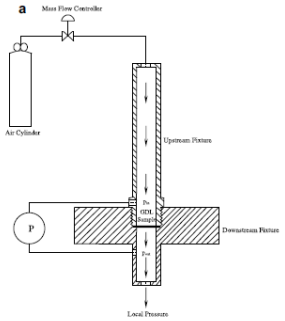
Porosity

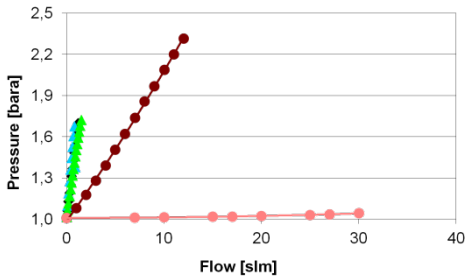


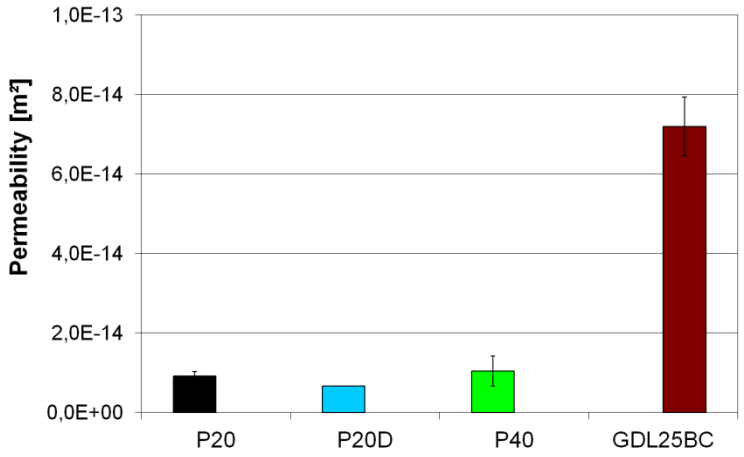
mercury intrusion porosimetry



Permeability







Commercial GDLs		In-house GDLs		
25BC	25BA	P40	P20	P20D

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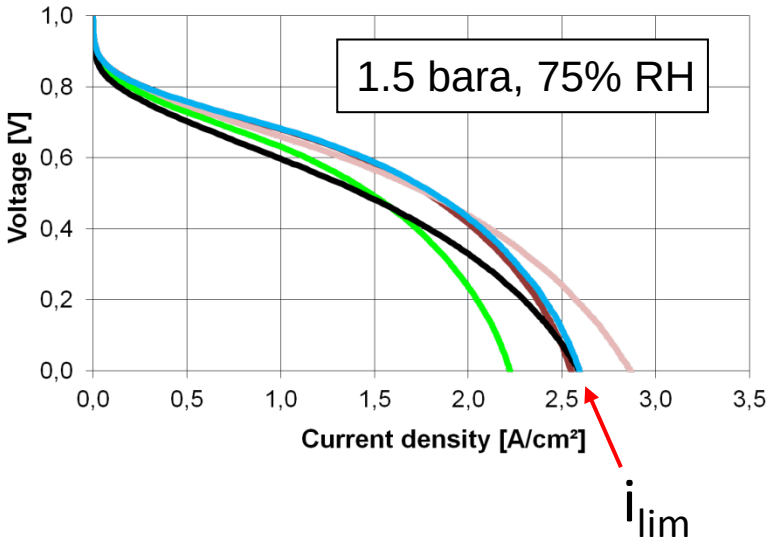
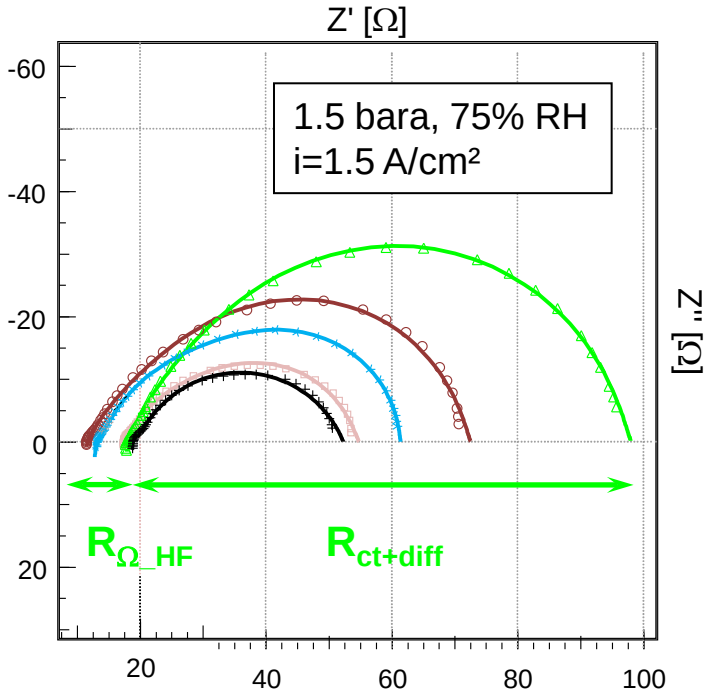
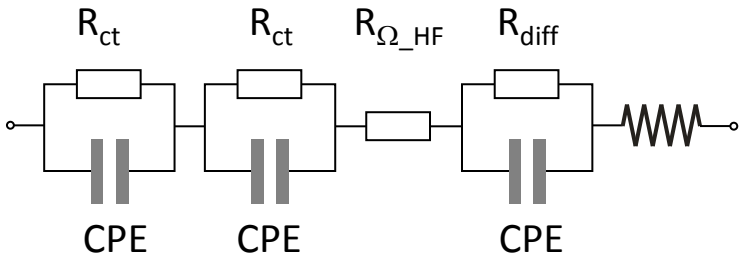
In situ characterization

In-situ characterization (5cm²):

CCM: Gore Primea 57MESGA
Anode: Sigracet GDL25BC from SGL Carbon
Cathode: GDL variation







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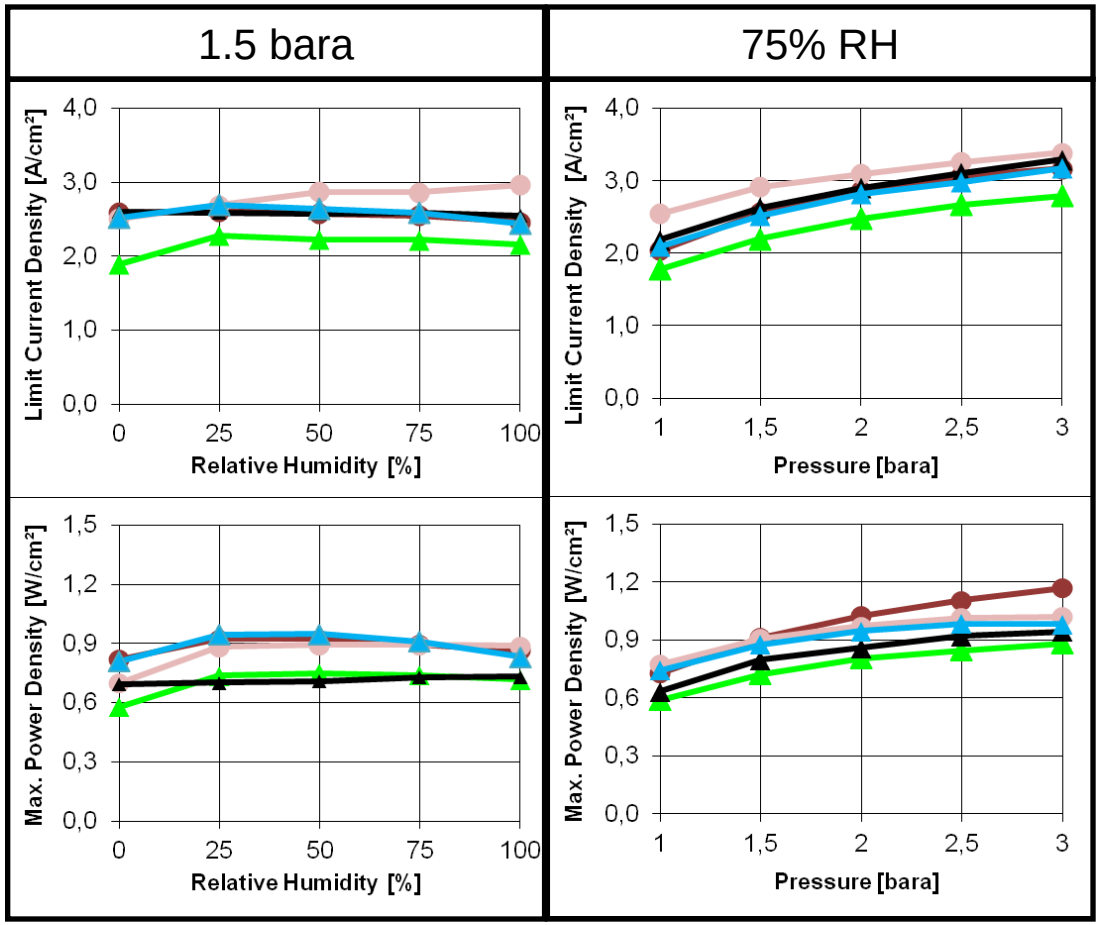
25BC	25BA	P40	P20	P20D

DLR

In-situ characterization (5cm²):

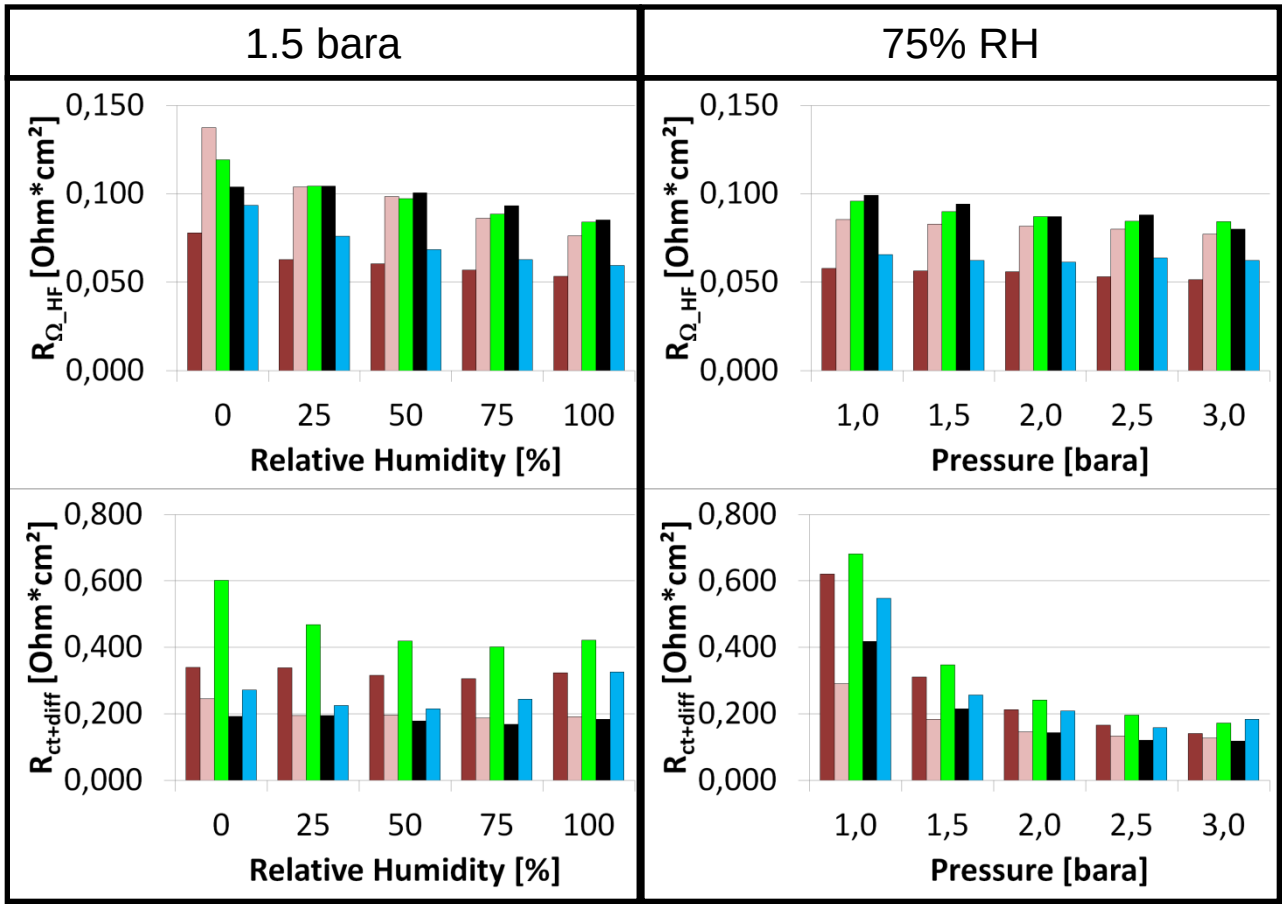


- w/o MPL: higher i_{lim}
- high PTFE content: low i_{lim} and P_{max}
- low PTFE content: higher i_{lim}, low P_{max}
- low PTFE content and double MPL thickness: higher i_{lim}, higher P_{max}

Commercial GDLs		In-house GDLs		
25BC	25BA	P40	P20	P20D

DLR

In-situ characterization (5cm²):



- w/o MPL: high R_{Ω_HF} lower $R_{ct+diff}$
- high PTFE content: high R_{Ω_HF} and $R_{ct+diff}$
- low PTFE content: high R_{Ω_HF} and low $R_{ct+diff}$
- low PTFE content and double MPL thickness: low R_{Ω_HF} and $R_{ct+diff}$

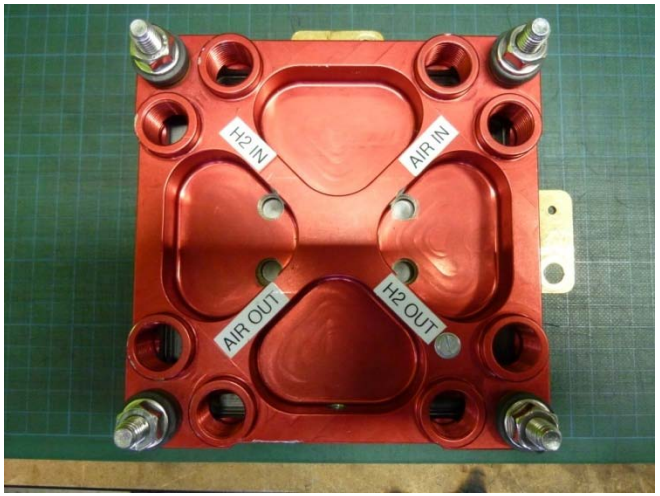
Commercial GDLs		In-house GDLs		
25BC	25BA	P40	P20	P20D

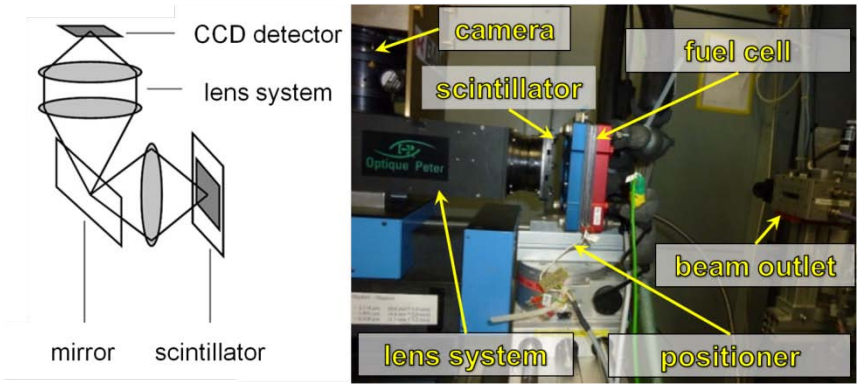
DLR

In situ radiography

Helmholtz-Zentrum Berlin
Bessy II

Zentrum für Sonnenenergie und Wasserstoff-Forschung





In situ investigation of water management of in-house MPL

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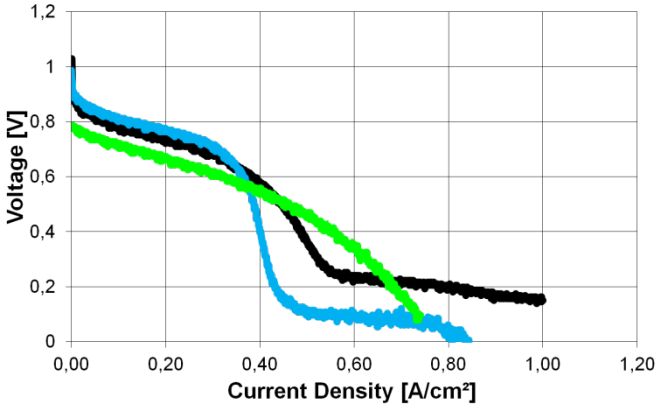
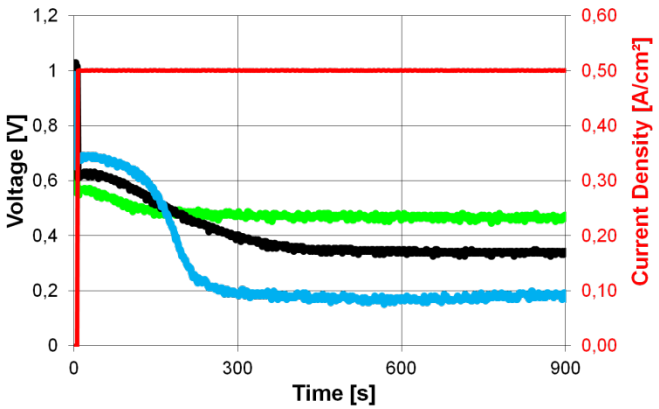
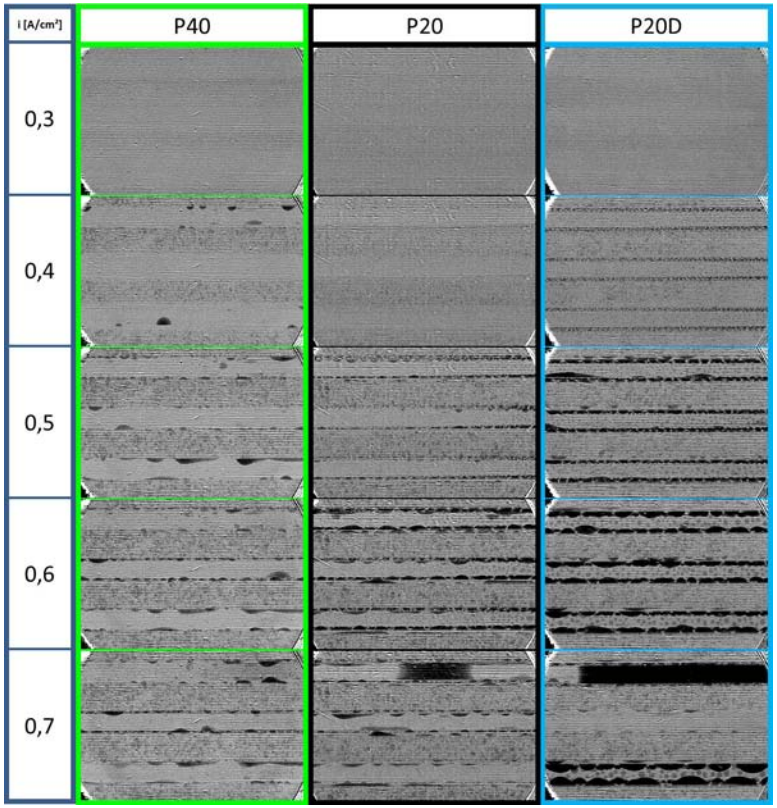
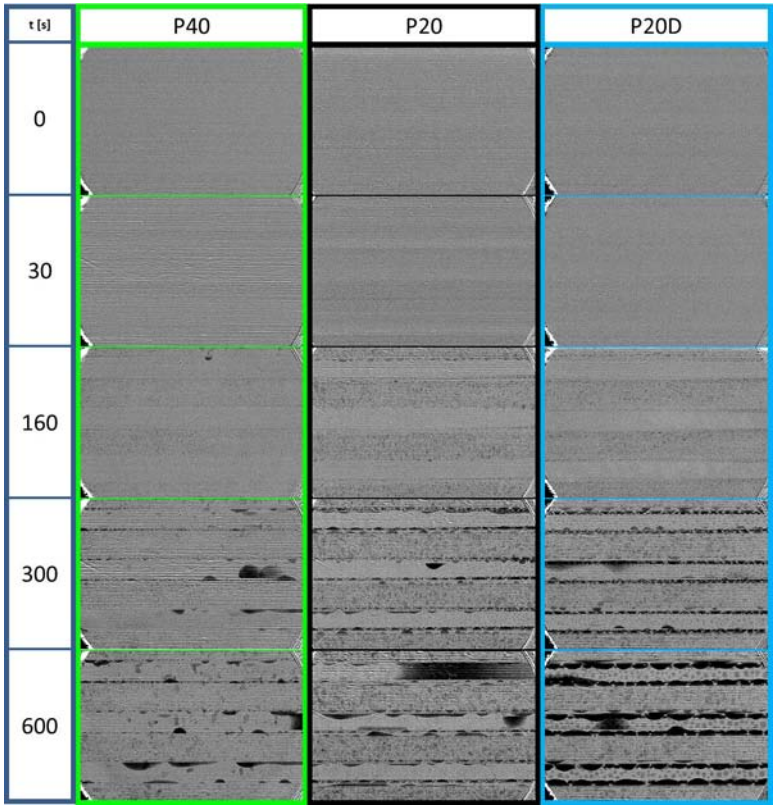

Voltage [V]
Current Density [A/cm²]
1,2
1
0,8
0,6
0,4
0,2
0
0,00
0,20
0,40
0,60
0,80
1,00
1,20


Voltage [V]
Current Density [A/cm²]
Time [s]
0
300
600
900
0,00
0,10
0,20
0,30
0,40
0,50
0,60


i [A/cm²]
P40
P20
P20D
0,3
0,4
0,5
0,6
0,7


t [s]
P40
P20
P20D
0
30
160
300
600

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Summary and conclusions:

- The comparison of GDL25BC and GDL25BA shows that the ohmic resistance of the MEA decreases with a MPL and the maximum power density increases, in spite of constricted gas transport

- A high PTFE content and thereby increased hydrophobicity of in-house MPLs is disadvantageous for the electrical conductivity and the gas permeability of the MEA at the same time.

- A low PTFE content and a high thickness of in-house MPLs decreases the ohmic resistance. That lead to high power densities, but high humidity conditions constricts the gas transport strongly. This could caused by the increased appearance of liquid water that in the synchrotron tests could be observed.

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Thank you for your attention