# Influence of the GDL on the operation of Anion Exchange Membrane Fuel Cells and High-Temperature Polymer Electrolyte Membrane Fuel Cells

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## Introduction

- Gas diffusion layers (GDL) are an important part of fuel cell membrane electrode assemblies MEAs.
- They need to:
  - distribute the reactants evenly over the catalyst layer surface;
  - facilitate the transport of chemical products like water from the catalyst layer to the flow field of the bipolar plate;
  - conduct electrons between bipolar plate and catalyst layer;
  - conduct heat from the catalyst layer to the bipolar plate
  - mechanically compensate uneven compression forces resulting e.g. from the fin-channel structure of the flow fields
  - compensate swelling and drying of the membrane upon wet-dry-cycles
- Within the BMDV funded project QM-GDL seven German research institutes have investigated
  - Effects of GDL properties on fuel cell performance
  - GDL ageing
  - Ways to measure relevant properties off-line or in-line of the product
- The goal was to determine ways to enhance quality assurance for this critical component.
- The main focus was on LT-PEMFC for heavy duty vehicle applications.
- Fraunhofer ICT additionally studied GDL effect on the operation of emerging fuel cell technologies AEMFC and HT-PEMFC

### Anion Exchange Membrane Fuel Cells (AEMFC)

- Anion exchange membrane fuel cells offer an alkaline electrode milieu and thus the chance to avoid platinum group metal catalyst.
- Also, many anion exchange ionomers are not bases on per- or polyfluorinated alkyls (PFAS)
- Due to the alkaline milieu water handling differs from acidic PEMFC
- Water is consumed in the cathodic oxygen reduction reaction

$$O_2 + 2\,H_2O + 4e^- \rightarrow 4OH^-$$

- And it is produced in the anodic hydrogen oxidation reaction

$$2\,H_2 + 4\,OH^- \rightarrow 2\,H_2O + 4\,e^-$$

- As the GDL has a strong influence on water management, divergences from the requirements of LT-PEMFC should be expected.

### High Temperature Polymer Electrolyte Membrane Fuel Cell (HT-PEMFC)

- As LT-PEMFC HT-PEMFC operate in an acidic milieu
- By using phosphoric acid doped polybenzimidazole membranes (PBI/$H_3PO_4$) the operating temperature can be shifted above 100 °C, typically 160 – 180 °C
- This has the following positive effects
  - Easier removal of produced heat
  - Higher tolerance against fuel impurities like CO
  - No occurrence of liquid water
- As no liquid water is present at operating temperature also here requirements to the GDL should differ.
- During activation in most cases phosphoric acid needs to diffuse from the membrane to the catalyst layer to establish ionic conduction connection of the catalyst.
- The acid must however not pass the catalyst layer into the GDL.
- Therefore, GDL properties might influence the durability of HT-PEMFC MEA.

## Results for anion exchange membrane fuel cell (AEMFC)

### Experimental procedures

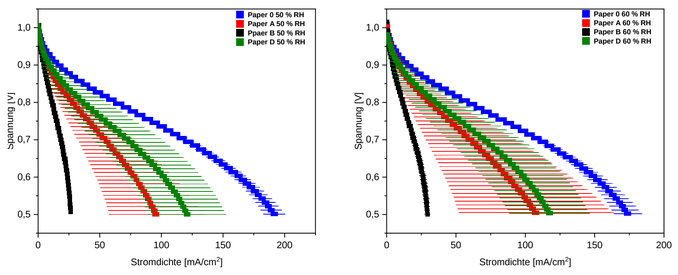
- For the AEMFC test five different paper GDLs with two different MPL or without MPL were tested

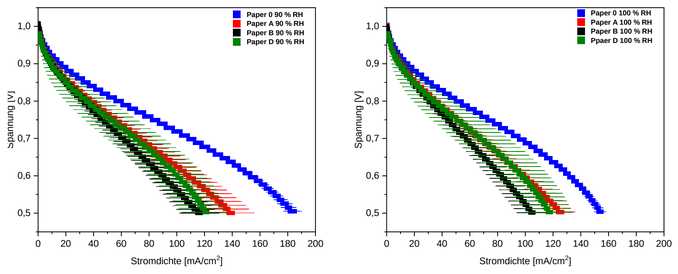
| GDL | MPL | Thicknes [µm] |
|---|---|---|
| Paper 0 | MPL 1 | 235 |
| Paper A | MPL 2 | 215 |
| Paper B | No MPL | 175 |
| Paper C | MPL 2 | 280 |
| Paper D | MPL 1 | 235 |

- For the AEMFC measurements reinforced anion exchange membranes type FAA-3-pk75 (BWT-Fumatech) were used
- Electrode were applied directly to the membrane in its bromide form by hand spraying
- Fumion ionomer at a loading of 17 wt.% was used as binder.
- The sprayed CCM were transferred into the OH-form using literature procedures.
- The CCM were assembled with the GDL to be tested by stacking them in a balticFuelCells qFC 25-100 cell holder and compressing them in-situ

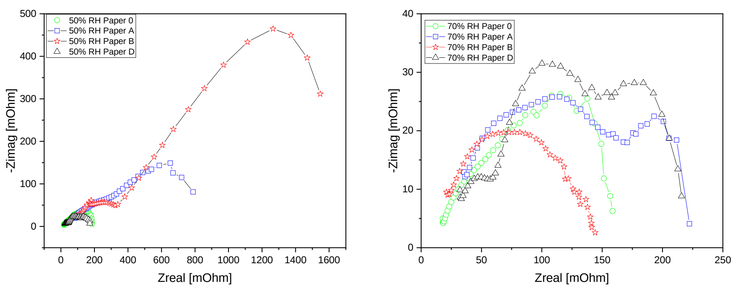
### Results

- In a first set of experiments the effect of relative humidity was tested with MEAs with the same GDL on both sides.




- The MPL had a strong influence on the cell performance.
- A strong impact of the GDL is also found in EIS results
- These do, however, not fully match performance results.




## Results for High Temperature Polymer Electrolyte Membrane Fuel Cells (HT-PEMFC)

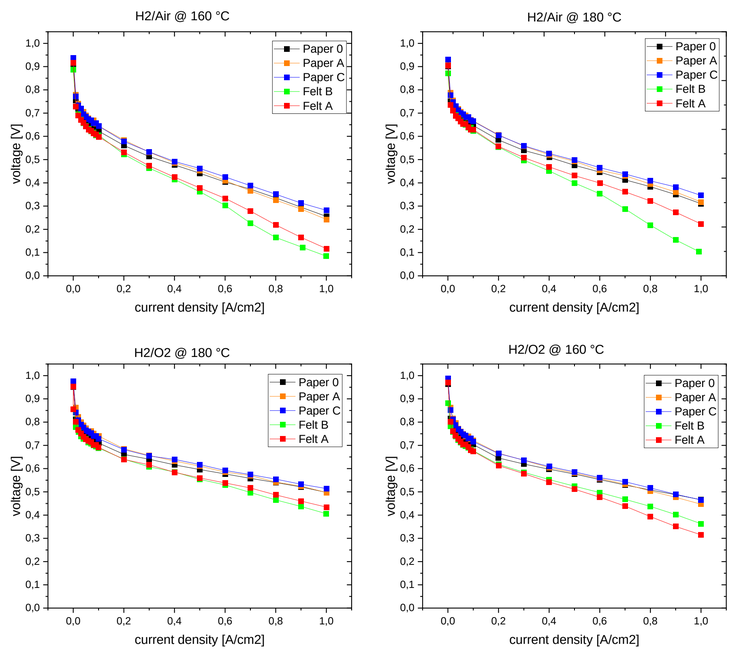
### Experimental procedures

- For the HT-PEMFC tests five different GDLs with different MPLs were tested.

| GDL | MPL | Thicknes [µm] |
|---|---|---|
| Paper 0 | MPL 1 | 235 |
| Paper A | MPL 2 | 215 |
| Paper C | MPL 2 | 280 |
| Felt A | MPL 3 | 180 |
| Felt B | MPL 4 | 230 |

- For the measurement Celtec® PBI/$H_3PO_4$ membranes were used.
- MEAs were made via the GDE route applying catalyst on top of the MPL of the GDL by hand spraying using PTFE as binder.
- The was produced GDEs were stacked with the membrane in the qFC 25-100 cell holder and compressed in-situ.
- The MEAs were tested by recording iV-curves with either air or oxygen as oxidant at 160 °C and 180 °C, respectively.

### Results




- In general, the paper type GDLs performed better than the felt type GDLs.
- Differences were smaller for operation with pure oxygen.
- This indicates that mass transportations might be the cause of the differences.
- From the papers the thickest paper C gave the best performance.
- For the felts under most conditions, the thinner felt A performed better.
- So here again, the MPL may play a role as they was different for the two types of felts.
- Also, the felt based MEAs showed larger differences in performance with temperature.

## Conclusions

- GDL has strong on both types of fuel cells.
- For the AEMFC the role of the MPL is of very high importance.
- For HT-PEMFC thicker paper type GDLs seem to be beneficial.
- An Impact of the MPL cannot be exclude.

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The presented results and opinions are in the sole responsibility of the authors.