Development of self-supporting MPLs for investigations of water transport in PEM fuel cells

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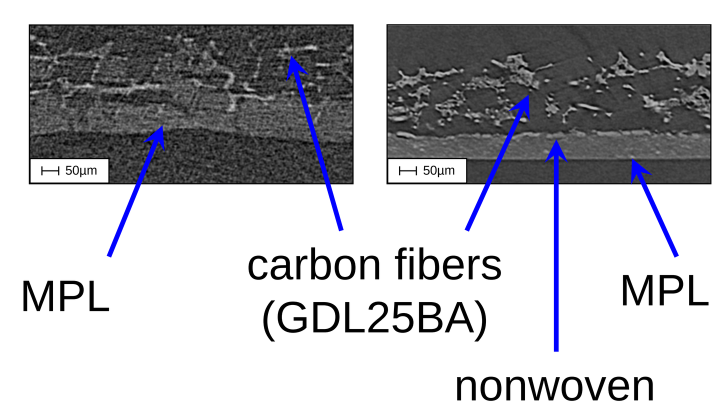
Introduction

The performance of a polymer electrolyte membrane (PEM) fuel cell has a strong dependence of its water management. The membrane needs humidity to have sufficient ion conductivity. But at high humidity, especially at high current densities, flooding of the electrodes can occur and consequently the available active area begins to decrease. The primary purpose of a micro porous layer (MPL) on a gas diffusion layer (GDL) is the effective wicking of liquid water from the catalyst layer into the diffusion media as well as reducing electrical contact resistance with the adjacent layers. To get information about the function of the MPL as an interconnection between the reaction layer and the macro porous carbon fiber substrate a self-supporting MPL was developed. This allows the manufacturing and the following treatments of the MPL independent from the GDL substrate and enables basically the measurement of MPL properties separately from the substrate.

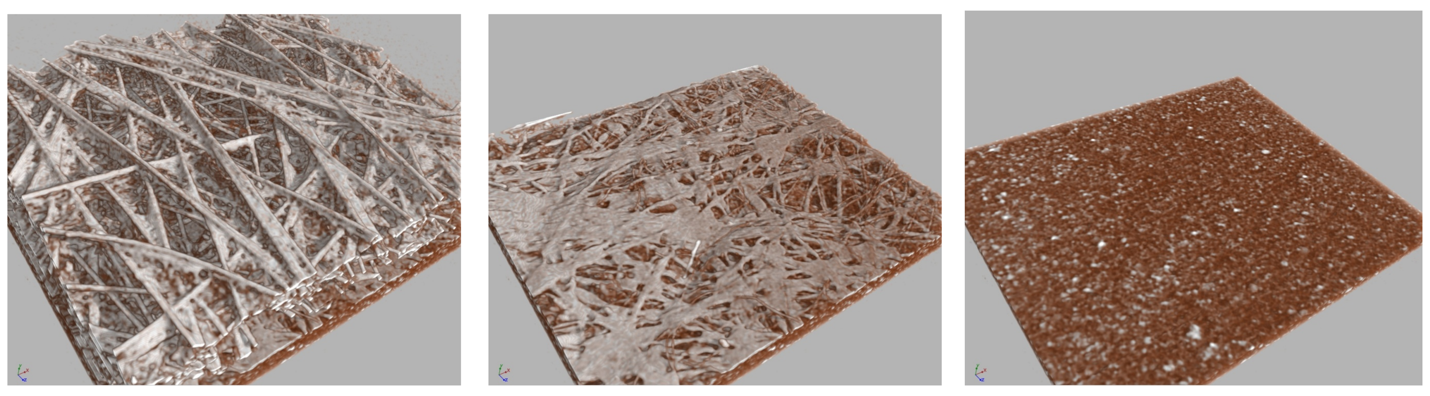
Materials

The MPL consists of a thin nonwoven of synthetics coated on one side with a mixture of carbon and PTFE produced by the dry spraying technology. This layer is pressed with the non coated side on a commercial GDL without MPL (Sigracet®GDL25BA from SGL).

CT micrographs



3D micrograph visualization of in-house GDL



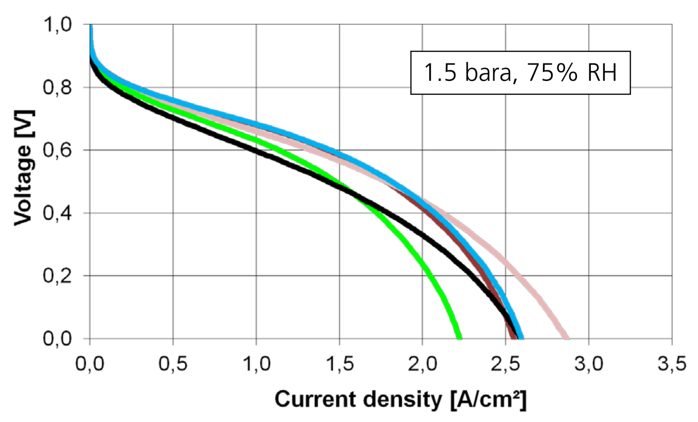
macro porous carbon fiber substrate | nonwoven of synthetics | mixture of carbon and PTFE

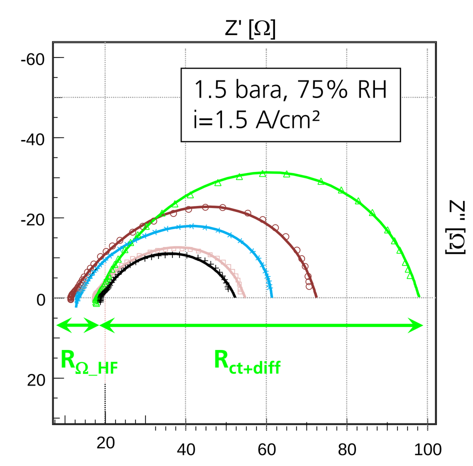
Experimental Results

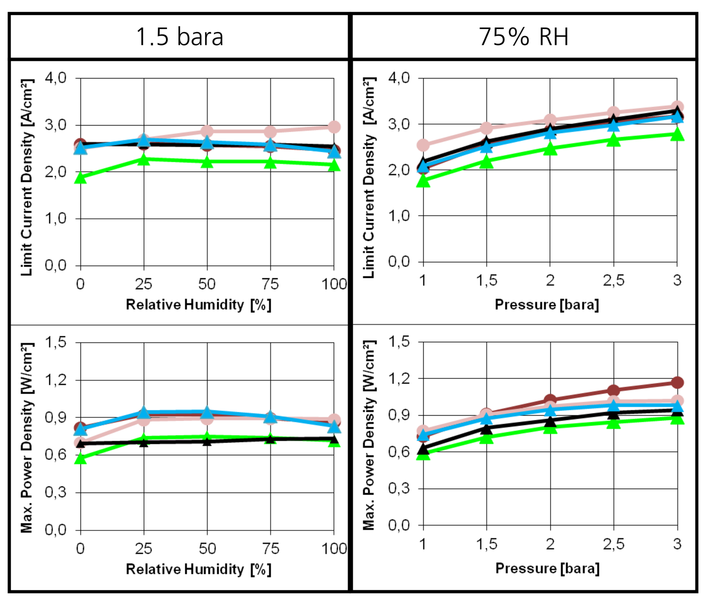
	Commercial GDLs from SGL Carbon			In-house GDLs		
	name			name	MPL-PTFE content	MPL thickness
■ (dark red)	GDL25BC		■ (green)	P40	40 wt.-%	40 µm
			■ (black)	P20	20 wt.-%	40 µm
■ (pink)	GDL25BA	GDL without MPL	■ (blue)	P20D	20 wt.-%	80 µm

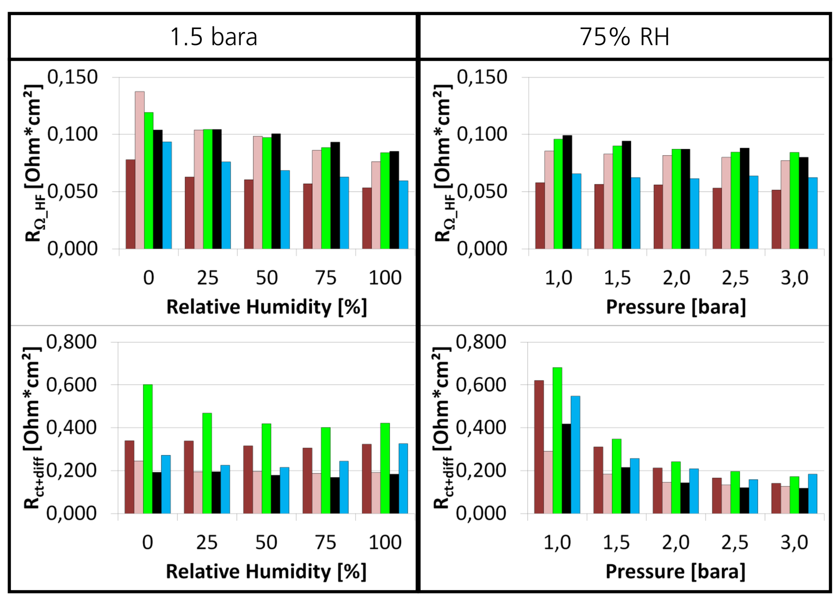
Electrochemical Evaluation

5cm² fuel cell setup, GDL variation on cathode side





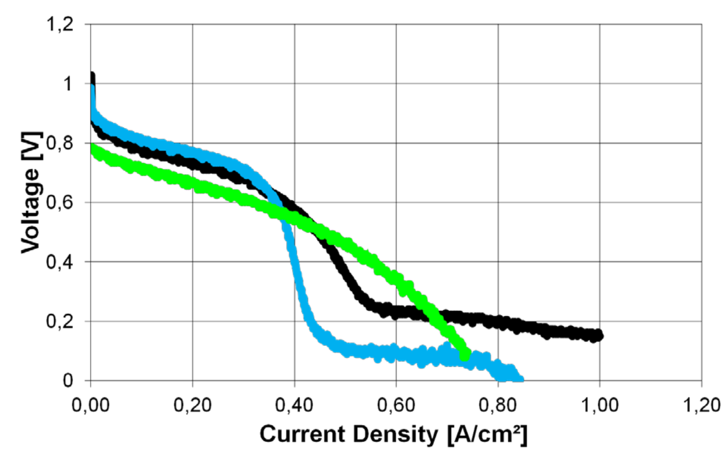


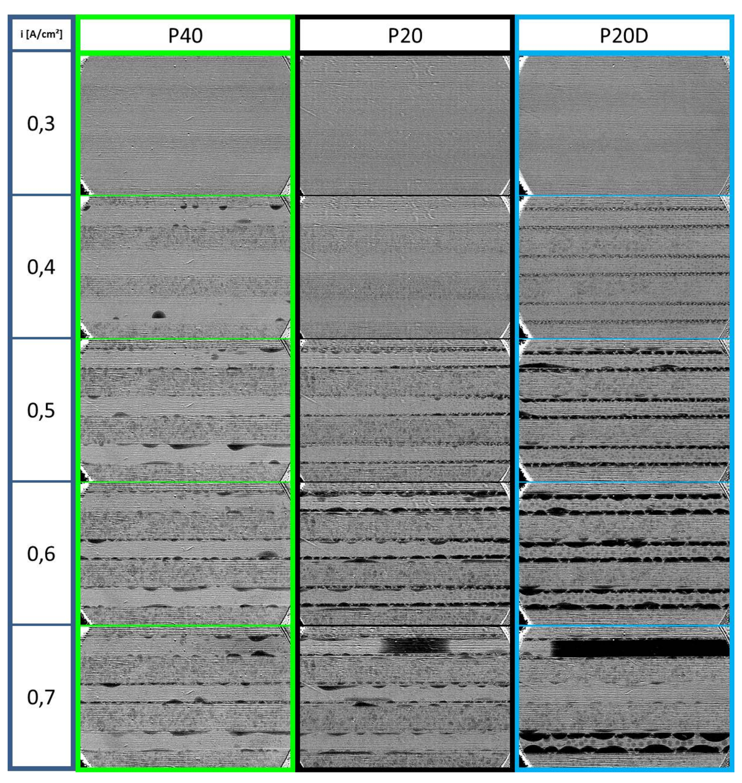


In-situ synchrotron imaging

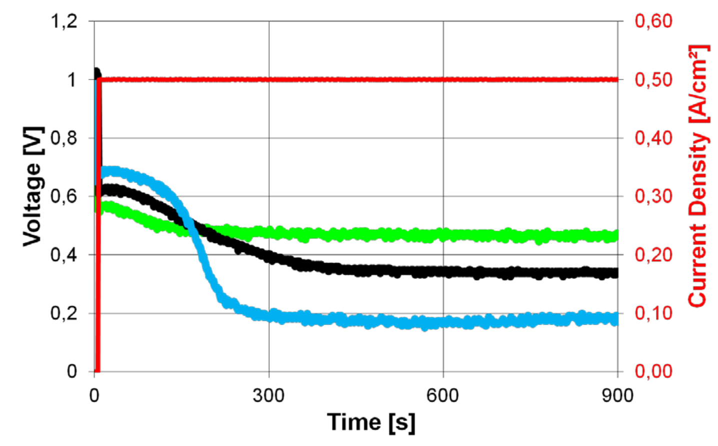
100cm² fuel cell setup , GDL variation on cathode side

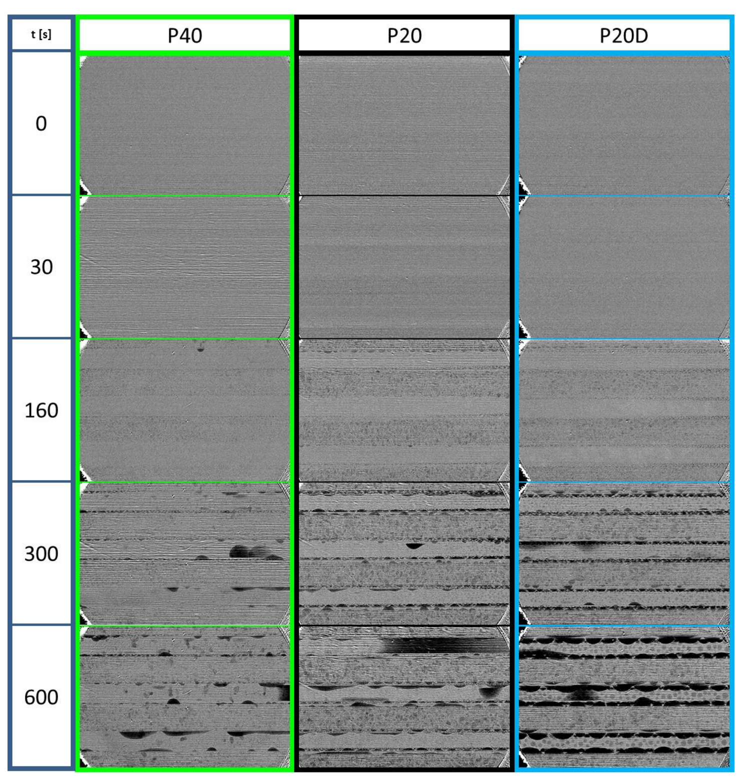
liquid water evolution with increasing current density





transient behavior of liquid water evolution after current step





Conclusions

The shown electrochemical tests indicate the following conclusions:

- The comparison of GDL25BC and GDL25BA shows that the ohmic resistance of the MEA decreases with a MPL.
- A high PTFE content 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 but high humidity constricts the gas transport. This could caused by the increased appearance of liquid water that in the synchrotron tests could be observed.

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