Investigations of the degradation of gas diffusion layer in PEFC

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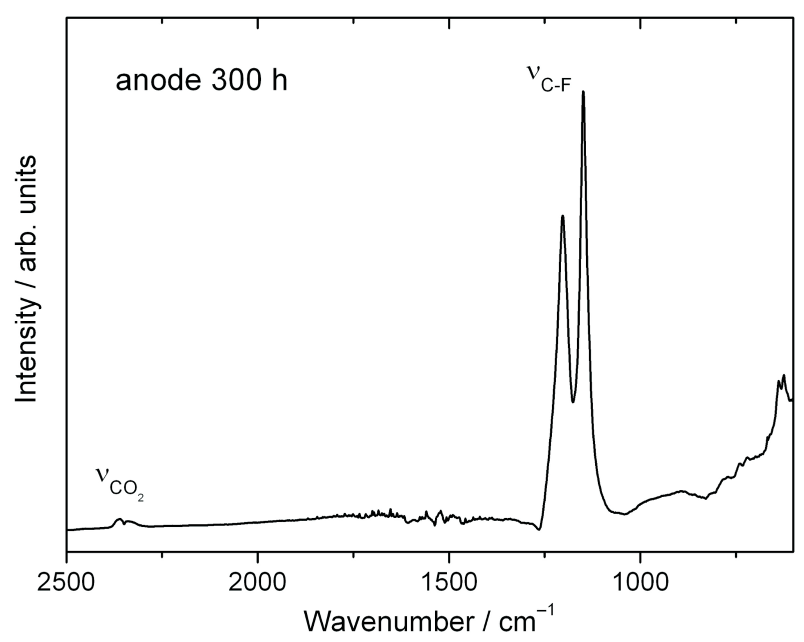
Introduction

Signifikant advances in the research and development of polymer electrolyte fuel cells (PEFC) have been reported in recent years. However, the water management in PEFC is one of the crucial parameters for the performance. Therefore, the adaption of the hydrophobicity is an important aspect for the optimization of fuel cells. The porous structures for the transport of the reactants as well as the transport of the water are mesoporous carbon structures. For the optimization of the transport processes and the water balance these carbon structure are hydrophobized by polytetrafluorethylen (PTFE). In addition, in some cases PTFE is also used in the reaction layers in order to make them hydrophobic.During long term operation of PEFC the performance decreases due to the degradation of the fuel cell components. Unfortunately, one of the degradation processes leads to an alteration of the hydrophobicity of the GDL and the raction layer. Due to a partially decomposition of the PTFE the hydrophobicity of the components will be reduced and consequently the water balance is changed. This degradation process has a strong effect on the cell performance, which can be morge significant than the other degradation effects because of the significance of water balance for fuel cell performance. Consequently, it is necessary to investigate and to understand the hydrophobicity alteration due to the degradation.The naturally and artificially aged GDLs were analyzed by X-ray photoelectron spectroscopy (XPS) as well as by Fourier transformed infrared spectroscopy (FTIR-ATR). With boths methods changes of the polymer could be observed. In addition, the GDLs were investigated by scanning electron microscopy (SEM).

Characterization of Gas Diffusion Layers

FT-IR Spectroscopy

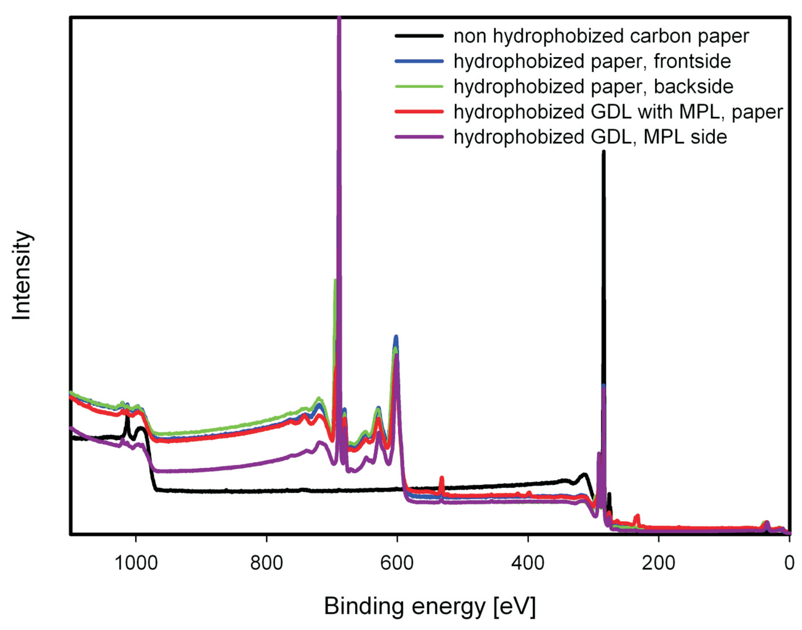
FT-IR spectroscopy has been performed to investigate the degradation behaviour of gas diffusion layers (GDL) for PEM fuel cells.

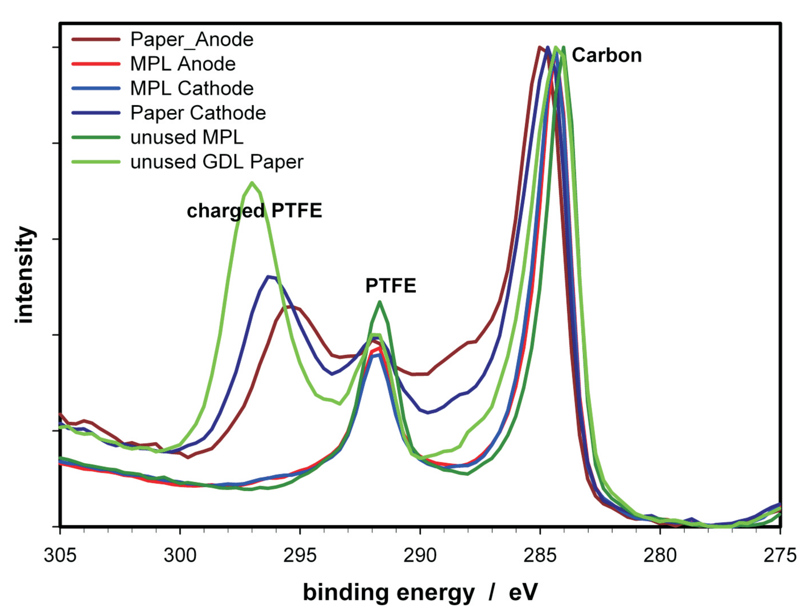


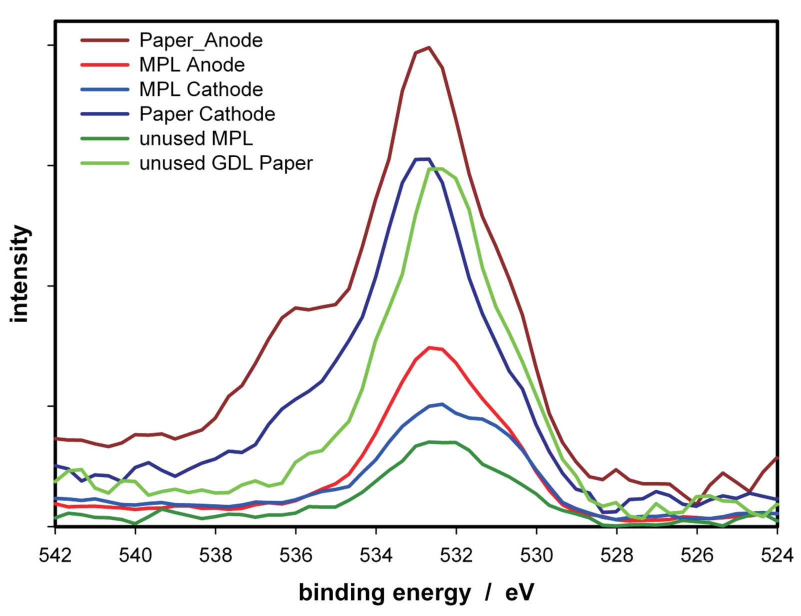
FT-IR spectrum of a gas diffusion layer (anode side) operated for 300 h in the range of 2500–600 cm^{-1}

X-ray Photoelectron Spectroscopy

The XP spectra show the different components on the surface of the GDL.



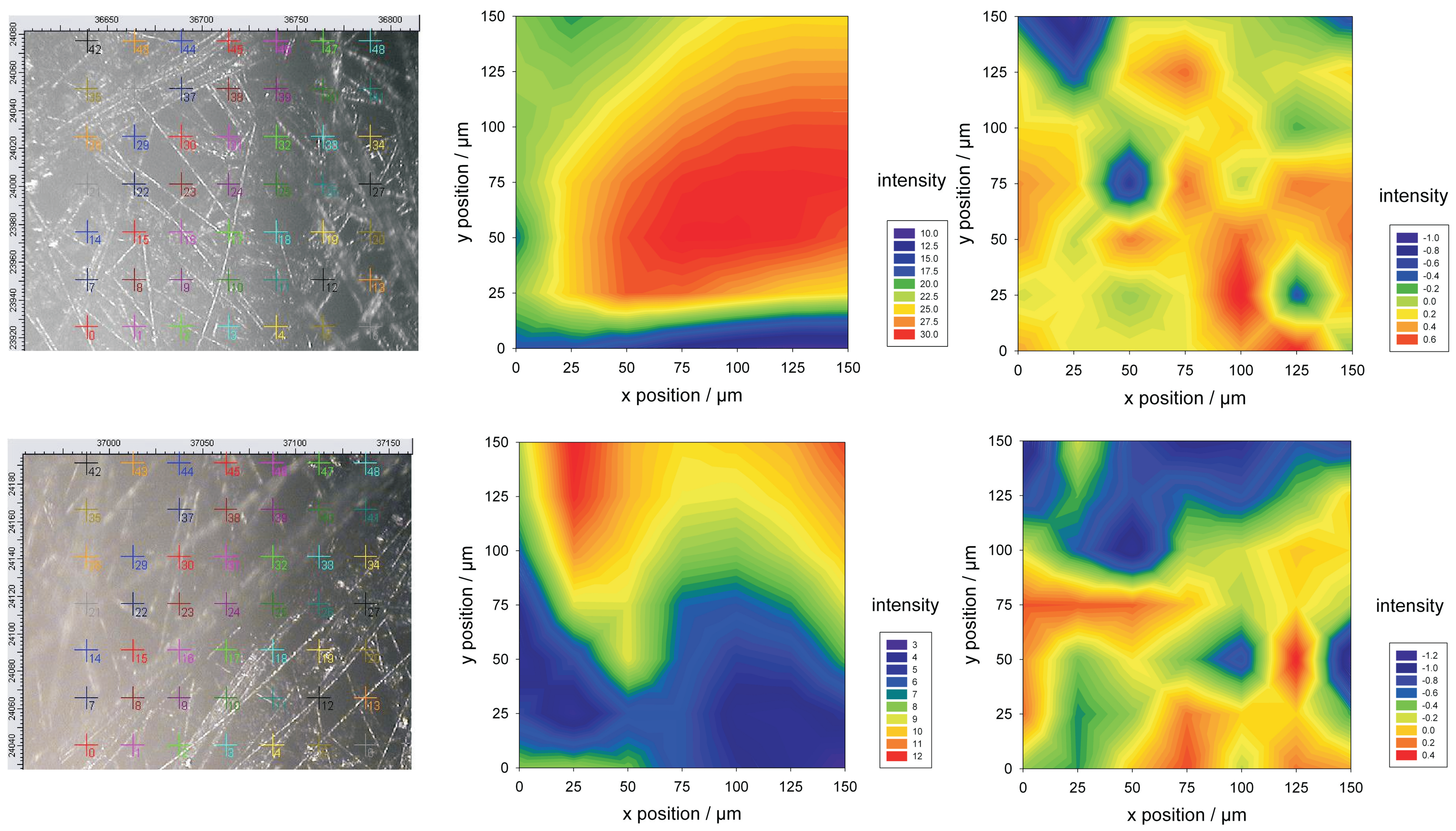




Top: XP spectra of used and unused GDLs
Middle: C 1s spectra of unused and used GDL
Bottom: O 1s spectra of unused and used GDL

FT-IR Spectroscopy - Mapping

To investigate the inhomogeneity of the GDL a FT-IR mapping with 7 x 7 points in an area of 150 x 150 µm has been recorded in order to depict the degradation process depending on the land and channel areas in the flow field.



Top:
Left: image of the investigated GDL (anode 300 h operation time) with flow field perpendicular with highlighted measurement positions (150 x 150 µm)
Middle: contour plot of the C-F vibration mode of the 7 x 7 spectra
Right: contour plot of the CO_2 vibration mode of the 7 x 7 spectra
Bottom:
Left: image of the investigated GDL (anode 300 h operation time) with flow field diagonal with highlighted measurement positions (150 x 150 µm)
Middle: contour plot of the C-F vibration mode of the 7 x 7 spectra
Right: contour plot of the CO_2 vibration mode of the 7 x 7 spectra

Conclusions

FT-IR Spectroscopy

- FT-IR spectra show C-F vibration modes from the polymer and CO_2 adsorbed on the surface
- FT-IR mappings indicate an inhomogeneous distribution of both the C-F and CO_2
- It is supposed that the inhomogeneity of the distribution of the polymer (C-F vibrations) is influenced by the flow field
- Due to fuel cell operation the intensity of the C-F bands decreases with the operation time (FT-IR)

XP Spectroscopy

- XPS allows to determine a quantitative analysis of the surface composition
- The C 1s signal allows the distinction of carbon black and PTFE
- The decomposition of PTFE is more significant on the anode side for both components, reaction layer and gas diffusion layer (XPS)
- An alteration of the oxidation state after operation can be observed (O 1s signal in the XP spectra)
- The changes of the CO_2 signals (FT-IR) should be correlated to the peak shift in the O 1s spectrum (XPS)

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