Improving segmentation of PEMFC x-ray tomographies

S. Vierrath[1], J. Haußmann[2], H. Markötter[3,4], I. Manke[3], J. Scholta[2], R. Zengerle[1], S. Thiele[1]

[1] Laboratory for MEMS Applications, Department of Microsystems Engineering - IMTEK, University of Freiburg, Germany
[2] Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW), Ulm, Germany
[3] Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Berlin, Germany
[4] Technische Universität Berlin (TU-Berlin), Berlin, Germany

Abstract

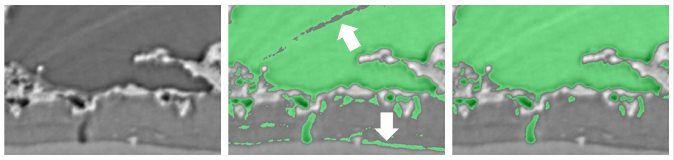
Proton exchange membrane fuel cell (PEMFC) performance strongly depends on morphology. Within the past years analysis by tomographic approaches has emerged as a valuable tool to assess morphology. Segmentation, the physical interpretation of 3D images, is a crucial step of tomography. In this study we compare different methods for segmentation of a gas diffusion layer/micro porous layer compound. We find that a mere threshold leads to erroneous segmentation and present a combined approach to overcome this problem.

Introduction

A PEMFC consists of various layers [1]. The gas diffusion layer (GDL) and the micro porous layer (MPL) play a pivotal role in electron conduction, gas diffusion and liquid water management. The complex interplay of these porous layers is yet not fully understood [2]. To investigate this interplay we employ x-ray tomographic methods imaging the morphology of these crucial layers. Segmentation is the process of discriminating the existing phases of a tomography. After imaging, segmentation strongly influences analysis which we emphasize in the following.

Segmentation

The given x-ray tomography shows a GDL/MPL-compound (Fig.1 a). To investigate water transport, solid and void phase of the compound have to be differentiated.



a) Raw image **b) Threshold** **c) Combined Approach**

Figure 1: X-ray tomography of GDL/MPL compound.

At first glance the gray value of a pixel appears as a good indicator for assigning it to a phase. As depicted in Fig. 2 the gray value distribution of the present tomography has two major peaks representing void and solid phase. However, when assuming a Gaussian distribution for each phase overlapping of the phase distributions can be observed.

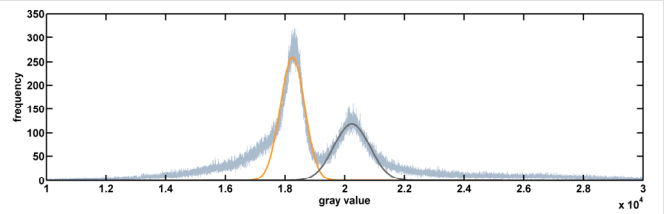


Figure 2: Gray value distribution of the x-ray tomography with two major peaks representing pore (left) and solid (right).

Thus a mere threshold, as commonly applied, fails to accurately separate: All gray values below a certain value (threshold) are assigned to void phase and above to solid phase. This leads to misassignments of the areas with gray values in the overlapping range. The result is depicted in Figure 1b showing misinterpretation of an x-ray artefact (upper left) and overestimation of void in solid (lower part).

We developed an approach that combines the strength and simplicity of a threshold with a stable algorithm for the overlap region. The latter algorithm exploits the fact that ambiguous values of void regions show high gradient direction variance enabling accurate segmentation. As depicted in Figure 1c the combined approach yields a very accurate segmentation.

Results

The erroneous segmentation hence leads to erroneous pore size distributions (PSD) and grain size distributions (GSD). This is due to too many big pores in void phase and too few big grains in solid phase (Fig. 3).

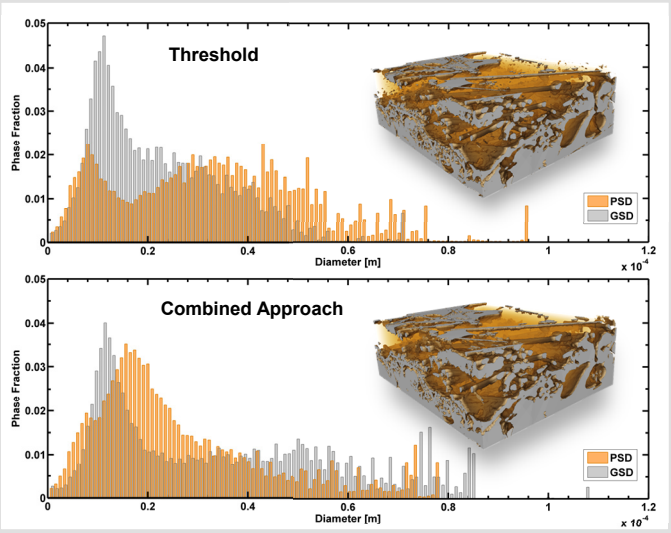


Figure 3: PSD and GSD of the GDL/MPL-compound.

Conclusion and Outlook

Accurate segmentation is crucial for subsequent analysis of an x-ray tomography. Our novel approach proofs to be far more accurate than state-of-the-art segmentation by a threshold.

However, the present approach represents a first step in the entire phase separation process. Future work includes identification of GDL fibers and binder as well as higher resolution imaging of microstructure.

Acknowledgement

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References

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