Abstract #1318, 224th ECS Meeting, © 2013 The Electrochemical Society

Micro-Computed Tomography Imaging of HT-PEM Fuel Cells under Contact Pressure Control

Maren Rastedt, F. Javier Pinar, Nadine Bruns, Anja Diedrichs and Peter Wagner
NEXT ENERGY · EWE Research Centre for Energy Technology at Carl von Ossietzky University, Carl-von-Ossietzky Str. 15, 26129 Oldenburg, Germany

Fuel cells are –as well known- very promising power converters, but there is still the exigency to increase their performance to be a marketable technology. Therefore we need a better understanding of the degradation processes and –effects influencing fuel cell performance and durability. Next to chemical degeneration, physical damage and/or degradation can play an important role and therefore stands in the focus of this work. All investigations presented here have been carried out with high temperature Polymer Electrolyte Membrane fuel cells (HT-PEMFC).

A HT-PEMFC Membrane-Electrode-Assembly (MEA) suffers under permanent physical stress during operation at temperatures around 160 °C. An example for such stress is the contact pressure which the bipolar plates (BPP) exert on the MEA. This contact pressure has influence on all components of the MEA and therefore may cause physical changes or even damages in all of them. For example, a high contact pressure may accelerate membrane thinning and could cause microcrack fractures (1).

Especially, the Gas Diffusion Layer (GDL) represents a critical component within a PEMFC and may have an enormous influence on the overall performance of the fuel cell (2, 3). Furthermore the GDL might be susceptible to degradation processes, chemically and mechanically. It can be shown, that the amount of failings and errors like disruptions accumulate with increasing contact pressure. First results about compression effects have already been published (4, 5). Figure 1 presents a µ-CT image of a MEA after 12 hours of compression with 2.5 MPa and 22 hours of relaxation. Here two typical degradation effects can be observed, firstly cracks within the Catalyst Layer (CL) (oval) and secondly fiber intrusion even into the membrane (circle). Therefore, HT-PEM-MEAs of two suppliers utilizing different GDL materials (carbon cloth and carbon paper), have been investigated with a fuel cell test station in operation with a compression unit, allowing to control the applied contact pressure on the MEAs. The measurements were accompanied by a thoroughly electrochemical characterization with polarization curves, electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and linear sweep voltammetry (LSV). While using MEAs with different GDL materials (cloth, paper) and BPPs with various Flow Fields (grid and serpentine), the influence of applied compressive force in combination with the flow field geometry on the MEA has been investigated and differences have been identified that will be reported here. In addition, the influence of increasing contact pressure on the MEA has been screened by ex-situ micro-computed tomography (µ-CT) investigations. Different resulting mechanical effects which can be identified within the µ-CT and SEM images will be shown and discussed, supported by additional results from the electrochemical characterization.

The µ-CT imaging in conjunction with Scanning Electron Microscopy (SEM) and the electrochemical characterization allows a more detailed examination of the degradation processes and effects which occur during fuel cell operation.

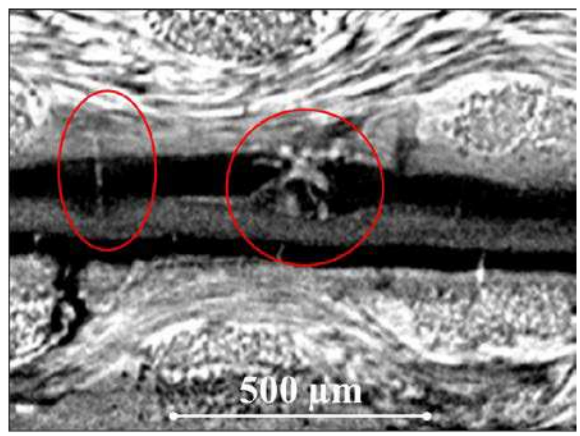

Figure 1: µ-CT-image of MEA (GDL: cloth) after 12 h of compression (2.5 MPa) and 22 h of relaxation

References:

1. R. Borup, J. Meyers, B. Pivovar, Y. S. Kim, R. Mukundan, N. Garland, D. Myers, M, Wilson, F. Garzon, D. Wood, P. Zelenay, K. More, K. Stroh, T. Zawodzinski, J. Boncella, J. E. McGrath, M. Inaba, K. Mivatake, M. Hori, K. Ota, Z. Oqumi, S. Miyata, A. Nishikata, Z. Siroma, Y. Uchimoto, K. Yasuda, K. Kimijima and N. Iwashita, *Chem. Rev*, **107**, 3904-3951 (2007).
2. N. Parikh, J. S. Allen and R. S. Yassar, *Fuel Cells*, **12**, 3, 382-390 (2009).
3. C. S. MacDonald, *Effect of Compressive Force on PEM Fuel Cell Performance*, University of Waterloo, Ontario, Canada, (2009).
4. A. Diedrichs and P. Wagner, *ECS Trans.*, **50**, 1137-1153 (2012).
5. A. Diedrichs, M. Rastedt, F. J. Pinar and P. Wagner, *J. Appl. Electrochem.*, *Submitted 2013*.