Reversible and Irreversible Degradation Phenomena in PEMFCs

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The presentation is focused on reversible and irreversible degradation phenomena in polymer electrolyte membrane fuel cells (PEMFCs). Analytical methods for the determination of component degradation will be presented and a new systematic approach for the analysis of reversible and irreversible degradation rates in an operating fuel cell will be introduced.

A detailed description of voltage loss rates and particularly of the discrimination between reversible and irreversible voltage losses will be given. A major motivation of the presented work is the lack of common description procedures and determination approaches of voltage losses in durability tests of fuel cell. This issue results in severe difficulties in the comparison of results obtained by different testing facilities or within different research projects especially if only one value for a degradation rate is reported. In order to systematically analyze voltage losses we have performed single cell durability measurements of several hundreds of hours in 25 cm^2 lab-scale cells. Specific test protocols containing regular refresh procedures were used for this purpose (see Figure 1). This enables distinguishing between reversible and irreversible voltage losses. To test the refresh procedures and analyze their effect on cell performance, parameters such as the duration of e.g. a soak time step have been varied. Between these refresh steps the cells were typically operated for 50 to 150 h. Conventional 5-layer MEAs with PFSA membranes, carbon supported Pt-catalysts and hydrophobized carbon fiber substrates with micro porous layers as GDLs were used for this study. For in-situ diagnostics of the operated cells polarization curves, impedance spectra, and CVs were recorded in order to determine the impact of the refresh procedures on the cells.

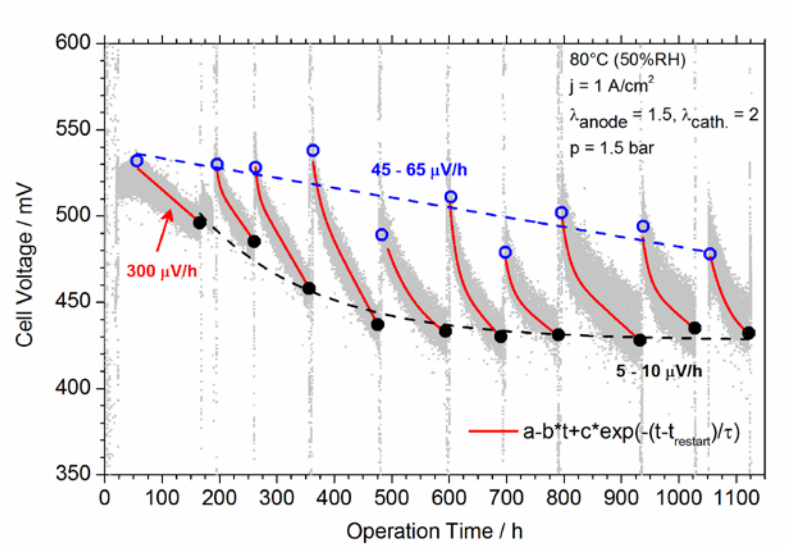

Figure 1. Specific tests containing refresh procedures for the determination of reversible and irreversible voltage loss in PEMFCs

Ex-situ methods were used to determine the causes for the reversible and irreversible voltage losses. Using different methods, detailed information about the physical composition of the individual fuel cell components can be obtained in order to optimize them and increase cell durability. Depending on the examined component and the analytical objective infrared absorption spectroscopy (FTIR), Raman, and X-ray photoemission spectroscopy (XPS) can be used to analyze the degradation effects and the sources for reversible and irreversible voltage loss during fuel cell operation. An overview of the different methods and their application will be given [1]. It will be shown, that a combination of complementary methods is necessary to gather a comprehensive view of the occurring processes and mechanisms. As an example, depth profiling techniques combined with XPS can be used to determine the composition changes inside the fuel cell electrodes [2], as shown in Figure 2.

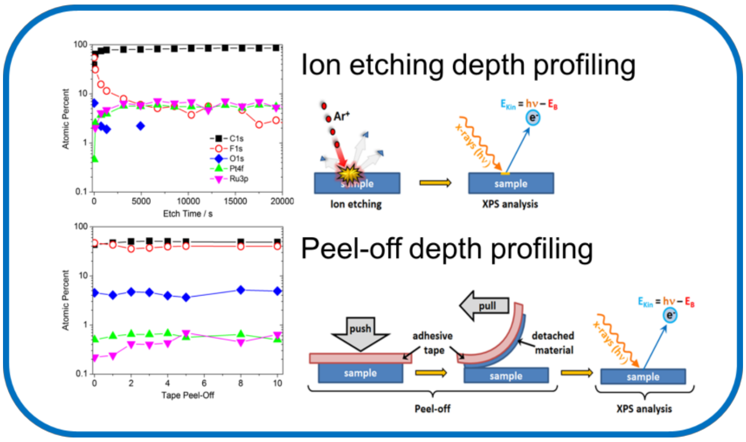

Figure 2. Depth profiling techniques for PEMFC component analysis

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References

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