FC-DIAMOND

PEM Fuel Cell Degradation Analysis and Minimisation Methodology Based on Joint Experimental and Simulation Techniques

Goal of the current project is the analysis and quantification of aging/degradation processes of the membrane-electrode-assembly (MEA) of low temperature PEM fuel cells (LT-PEMF) based on a joint experimental/simulation-based technique. Utilizing a 3D-simulation approach, suitably extended based on experimental aging/degradation studies, "virtual experiments" related to membrane aging and catalyst degradation are conducted for selected membrane-electrode-assemblies adopting different global platinum content and spatial platinum distribution patterns. Simulation results of the temporal/spatial evolution of degradation processes enable their correlation with geometrical cell details and local operating conditions. Validation of the transferability of the developed technique to the analysis and quantification of degradation phenomena in real-life PEM fuel cells is done via simulation of differently aged cells adopting industrial flow fields and comparison of the obtained results with experimental data.

Fuel-cell powered electric vehicles are highly efficient, and when fuelled with H2 do not emit any harmful pollutants. Adopting electrolysis, H2 can be produced with electrical energy from renewable sources (e.g. wind energy) without emissions. In the automotive sector, low-temperature PEM fuel cell (LT-PEMF) powered vehicles are introduced to the world-market by the major OEMs (Toyota, Hyundai, Honda, BMW, Daimler, Ford, GM, Nissan, Volkswagen, etc.) in larger numbers with beginning of 2015. However, the costs of the fuel cell systems of the vehicles are still too high and cannot be reduced sufficiently by scale effects of the beginning serial production. Still, the material costs of the platinum required for the cells play a significant role besides the costs for the proton-conducting membrane. A reduction of the platinum content, especially on the more performance critical cathode side of the membrane-electrode-assembly (MEA) has a direct impact on the activity of the catalyst layer and hence on the performance of the cathode and the whole fuel cell. However, a reduction of the platinum content has dramatic negative consequences on the cell aging/degradation rate.

The focus of the current project is on the analysis and quantification of aging/degradation processes of the membrane-electrode-assembly (MEA) of low temperature PEM fuel cells (LT-PEMF) based on a joint experimental/simulation-based technique. Utilizing a 3D simulation approach, suitably extended based on experimental aging/degradation studies, "virtual experiments" related to membrane aging and catalyst degradation are conducted for selected membrane-electrode-assemblies adopting different global platinum content and spatial platinum distribution patterns. Simulation results of the temporal/spatial evolution of degradation processes enable their correlation with geometrical cell details and local operating conditions. Validation of the transferability of the developed technique to the analysis and quantification of degradation phenomena in real-life PEM fuel cells is done via simulation of differently aged cells adopting industrial flow fields and comparison of the obtained results with experimental data.

As a result of the project a technique will be available in the future that enables the simulation based evaluation of the degradation processes in the MEA. The model uses conditions in the cell (operating conditions) and cell component assembly related Information as input parameters, and then enables assessment of the impact of platinum loading, spatial platinum distribution or cell geometrical details on performance change with time. Adopting this model based approach, it will be possible in future to investigate a distinct set-up, composed of a dedicated MEA or single cell configuration and well defined operating conditions with respect to its behavior over lifetime. Based on the simulations it will be possible to answer questions regarding MEA-configuration with focus on the cathode-side by simultaneously determining the most ideal operating conditions.

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