A transient 2D PEMFC model to investigate cell performance and degradation

T. Jahnke[1], G. Futter[1], A. Latz[1,2]
[1]*German Aerospace Center (DLR), Institute of Engineering Thermodynamics, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany*
[2]*Helmholtz Institute Ulm for Electrochemical Energy Storage (HIU), Helmholtzstraße 11, 89081 Ulm, Germany*
thomas.jahnke@dlr.de

Performance degradation still poses a major challenge for polymer electrolyte membrane fuel cells (PEMFCs). A better understanding of the underlying degradation mechanisms and the influence of the operating conditions is crucial in order to be able to predict cell performance and durability. Detailed physical models allow identifying and investigating these mechanisms and represent important tools for optimization of cell performance and reduction of degradation.

Here, we present a transient, two-dimensional single cell model for PEMFCs implemented in our in-house code NEOPARD-FC, which is based on the open-source framework DuMux [1]. The model is non-isothermal and includes electrochemistry, two-phase multi-component transport in the porous layers as well as water and gas permeation through the membrane.

Simulations of polarization curves and impedance spectra under various operating conditions are performed to validate the model. The validated model provides insights on the local conditions within the cell which are often not accessible in experiments. In particular, we focus on the water management which plays an important role for cell performance. Furthermore, analysis of the simulated impedance spectra allows evaluating the influence of processes such as proton conductivity, oxygen transport, etc. on the overall cell performance.

By coupling the cell model with models of degradation mechanisms our framework can also be used to investigate degradation phenomena. In doing so the cell model provides the local conditions within the cell which then determine the local degradation rates. Here, simulations of membrane degradation by coupling the cell model with a detailed chemical membrane degradation model are presented.

References:
[1] B. Flemisch, M. Darcis, K. Erbertseder, B. Faigle, A. Lauser, K. Mosthaf, et al., Advances in Water Resources **34** (2011) 1102–1112.