A 2D two-phase model to investigate the performance and degradation of PEMFCs

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Polymer electrolyte membrane fuel cells (PEMFCs) are environmentally friendly alternatives to conventional energy conversion systems. However, from the theoretical point of view the PEMFC functionality is determined by the complex interplay of numerous processes occurring on various scales. The development of detailed physical models can help to identify and investigate the underlying mechanisms and provide important information on the local conditions within the cell which are often not accessible in experiments.

Here, we present a transient, two-dimensional PEMFC model 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, charge transport, 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 provide interesting insights on the relevant mechanisms and allow for a reliable model validation. On the basis of the validated model, the occurrence of heterogeneities within the cell is discussed. Particular focus is given to the water management which plays an important role for cell performance.

The cell model additionally provides the basis for studying degradation phenomena like membrane or catalyst degradation which depend on the local conditions within the cell. Simulations of PEMFC degradation by coupling the cell model with degradation models are presented.

References:

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