Studying PEM Fuel Cells Using Equation Based Simulation

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Abstract

We present computer simulation results for PEM fuel cells using COMSOL Multiphysics® software. We have developed novel PDE equations at NPL from first principles and these are more realistic than models typically used in literature. The theory includes Maxwell-Stephan and Nernst-Planck equations for the diffusion and electrochemistry as well as equations governing electrostatic and stress/strain effects. The whole system is a highly coupled multiphysics and non-linear problem with particular complexity arising from the electrochemical source terms which include an agglomerate model. We present these and their derivation equations in this talk and show how we used COMSOL to solve them using two techniques: combining built in capabilities and using equation based modelling to enter equations explicitly using the "coefficient mode". The latter mode allows us more control over exactly what equations are solved and will help us to generalise the model to include Navier-Stokes equations for the stress/strain behaviour. In this presentation we compare these different methods of using COMSOL and show preliminary results from our simulations including polarisation curves which are compared to experiments.

Figures used in the abstract

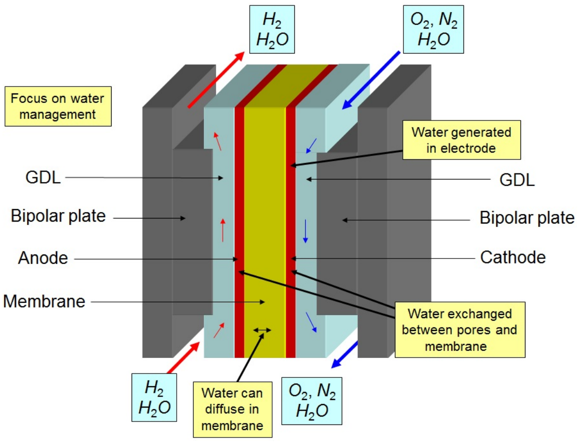

Figure 1: Representative volume element of hydrogen fuel cell

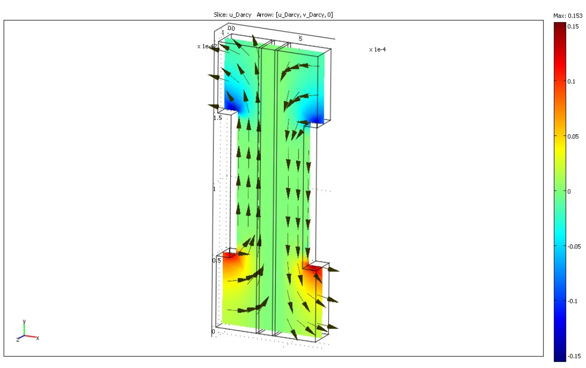

Figure 2: COMSOL simulation result: velocity field in the fuel cell with input and output ports

Figure 3

Figure 4