Physical modeling of direct methanol fuel cells

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Our basic model of a DMFC describes the through–plane transport of reactants and charges and the consumption of feed molecules along the channel. Large ratio of channel length to the MEA thickness makes it possible to split the fully 2D problem into a 1D through–plane problem and a 1D problem in channels. This idea was utilized some 20 years ago by Fuller and Newman in numerical modeling [1]; we employ this approach to construct analytical models.

The idea of spitting will be illustrated with the model of the cathode side of a hydrogen cell and compared to experiments [2]. Then we will discuss the quasi–2D model of a DMFC; using this model the effect of gaseous bubbles in the anode channel on cell performance will be rationalized [3].

At low oxygen flow rates the model gives unexpected solution: current density appears to be localized close to the oxygen channel inlet. Furthermore, even at vanishingly small current in the load, local current density at the oxygen channel inlet remains constant. This explains lowering of cell open–circuit voltage (mixed potential) [3].

In order to verify this effect we have designed a linear cell with the straight channels and segmented electrodes. The results of experiment with this cell confirm the model predictions discussed above. Moreover, we have found that the oxygen–depleted part of the cell turns into electrolysis mode and it serves as a "load" for the galvanic (oxygen–rich) domain [4].

Further studies have shown that operation in electrolysis mode improves galvanic performance of the cell. Periodical "activation" of cell by running it for several seconds in electrolysis mode improves galvanic performance by 10–30% [5].

Under certain conditions hydrogen produced in the electrolytic domain is utilized within the cell as a fuel. Finally, we discuss this *direct methanol–hydrogen fuel cell* [6].

References

[1] T. F. Fuller and J. Newman. *J. Electrochem. Soc.*, **140** (1993) 1218.

[2] D. J. L. Brett, S. Atkins, N. P. Brandon, V. Vesovic, N. Vasileiadis, and A. R. Kučernak. *Electrochem. Comm.*, **3** (2001) 628.

[3] A. A. Kulikovsky. Analytical modeling of a direct methanol fuel cell. In T. S. Zhao, K.D.Kreuer, and T.Nguyen, editors, *Advances in Fuel Cells*, volume 1, pages 337–418. Elsevier, New–York, 2007.

[4] A. A. Kulikovsky, H. Schmitz, K. Wippermann, J. Mergel, B. Fricke, T. Sanders, and D. U. Sauer. *Electrochem. Comm.*, **8** (2006) 754–760.

[5] A. A. Kulikovsky, H. Schmitz, K. Wippermann, J. Mergel, B. Fricke, T. Sanders, and D. U. Sauer. *J. Power Sources*, (2007, in press).

[6] A. A. Kulikovsky, H. Schmitz, and K. Wippermann. *Electrochem. Solid State Lett.*, (2007, in press).