Mitigating mass transport limitations of PEFCs during dynamic operation

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The performance and lifetime of polymer electrolyte fuel cells are very much dependent on internal conditions and modes of operation. During steady state operation of the fuel cell, the conditioning parameters like stoichiometry, pressure, temperature and humidity can be continuously adjusted to achieve a constant high performance of the fuel cell. In dynamic operation of the fuel cell, it is very challenging to monitor and control the fast changing conditions inside the cell.
Fast and disruptive changes are performed in these experiments either by load or voltage steps. By observing the voltage response of a load change it is possible to get fundamental details on the mass transport mechanisms inside the fuel cell. Fig. 1 shows a typical voltage response of polymer electrolyte single cell caused by a step load change. It can be seen that the cell voltage decreases and the single electrode potentials are not considered here [1,2]. The single electrode potentials also change and the sum of the single potentials create the observed voltage drop. The critical under- and overshoot as well as the delay time to reach the steady state are indicated by the green lines. These phenomena are caused by mass transfer limitations that occur if the supply of protons and electrons cannot match the current demand of the load.

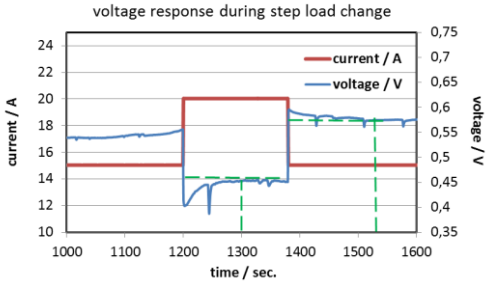

Figure 1. *Voltage response of a step load change*

The under- and overshoot can cause harmful voltage levels that accelerate the degradation of the cell. The low voltage after an increasing load step is caused by membrane dry out. The dry out is generated by a combination of heat production on the cathode and electroosmotic drag on the anode. This causes a resistance increase (vice versa for the stepwise load decrease). The course of the resistance follows an exponential curve until the membrane humidity reaches the corresponding steady state level. The time that is necessary to reach steady state conditions is corresponding to the hydration time of the membrane after the dry out. To counteract these undesirable effects, the increase of gas humidity, stoichiometry or gas pressure is possible. The extent of humidity, stoichiometry and pressure increase to vanish voltage over- and undershooting depends on the range of the load step and the initial operation conditions. To gain more insides of these effects a series of voltage cycle experiments will be conducted within the ongoing project 'KeyTech4EV'. A suitable monitor technic and control strategies for the fuel cell, balanced between efficiency and life time, will be discussed.

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References

1. Baumgartner W.R., Parz P., Fraser S.D., Wallnoefer E., Hacker V. (2008) J. Power Sources, 182, 413–421.
2. Ramschak E., Baumgartner W.R., Hacker V., Prenninger P. (2008) World Electric Vehicle Assoc. J., 2, 23–29.