Break down of losses in thin electrolyte SOFCs

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To be able to focus SOFC development work it is highly desirable to be able to break down the electrical losses observed on the full cell into individual components ascribable to one of the cell components (anode, cathode or electrolyte) or even into individual processes at either of the electrodes. This is a non-trivial task. On thin electrolyte cells it is effectively impossible to use a reference electrode to split the losses between the two electrodes [1,2], and inevitably one has to analyze the full cell response, which is the "sum of many different processes".

In this study it is demonstrated how the diffusion losses in the anode-support may be determined and how the cell resistance can be subdivided into purely ohmic losses, losses due to gas-diffusion in the anode and the sum of anode- and cathode-loss. This splitting is achieved using results of impedance and DC-tests obtained in different gas atmospheres at various temperatures in combination with simple models of the diffusion losses.

IV-curves on an anode supported thin electrolyte cell (CO475) with a typical performance of DK-SOFC-cells produced ultimo 2001 are depicted in Figure 1. The area specific resistances deduced from the curves after correction for the non-negligible fuel utilization are also shown. The increasing resistance at high current density is due to oxygen utilization, but the curvature at low current density, and specifically the difference between the two curves (5 % and 21 % water in inlet) is a fingerprint of diffusive losses in the anode. In the bottom of the figure the prediction of a simple model of the diffusive loss is illustrated. The model is seen to account very well for the observed current dependence of the resistance, as well as for the difference between the resistances observed with different water vapor content. The effective diffusion constant deduced from the best-fit curve is $4.7 \cdot 10^{-6}$ m^2/s. This is about 0.5 % of the binary diffusion constant for unhindered transport with this atmosphere.

Figure 2 shows measured and calculated equivalent diffusion resistances deduced from impedance data on CO475. The best fit corresponds to an effective diffusion constant of $4.5 \cdot 10^{-6}$ m^2/s, which is in good agreement with the value obtained from the DC-curves in Fig. 1.

Figure 3 shows impedance spectra obtained on an anode supported cell (PC0030, may 2002) at 850 ^{o}C with different anode gas streams. Diluting the gas mainly affects the low frequency response of the cell (<100 Hz). Specifically, a pronounced effect of the diluting gas is observed below 10 Hz. After correcting for the conversion impedance the low frequency resistance observed in the four cases is found to scale in direct inverse proportion to the calculated ternary diffusion constants of the gas mixtures.

The diffusion losses on DK-SOFC anode supported cells were deduced from impedance and DC-tests in different gas atmospheres. The losses are non-negligible at 850 ^{o}C considering performance of state-of-the-art cells [3]. Careful treatment of the conversion and diffusion losses allows the cell losses to be broken down into ohmic losses, diffusion losses and the sum of anode- and cathode-losses.

REFERENCES

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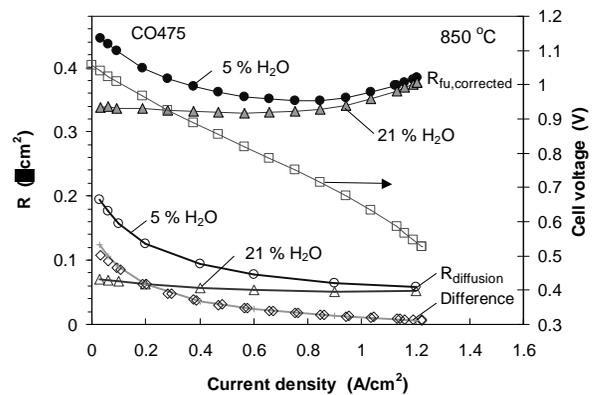
Figure 1. IV-characteristic of an anode supported thin electrolyte cell (CO475) and the cell resistance deduced from the curve. Also shown is model predictions (labelled 'R$_{diffusion}$') of the diffusive losses for the two inlet gas compositions (different water contents) as well as the difference between the resistances in the two cases (symbols) and the model prediction for this difference (solid line, 'difference').
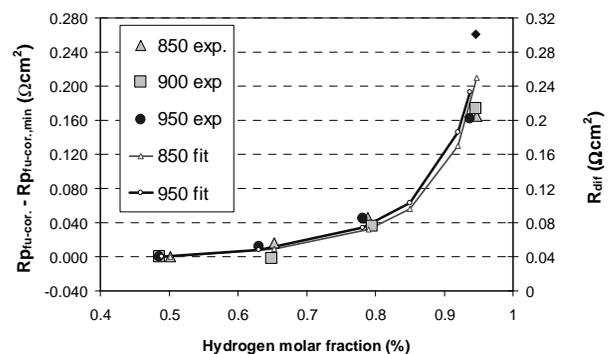

Figure 2. Measured (symbols) and calculated (lines) anode diffusion losses on CO475 deduced from impedance measurements carried out at different temperatures.
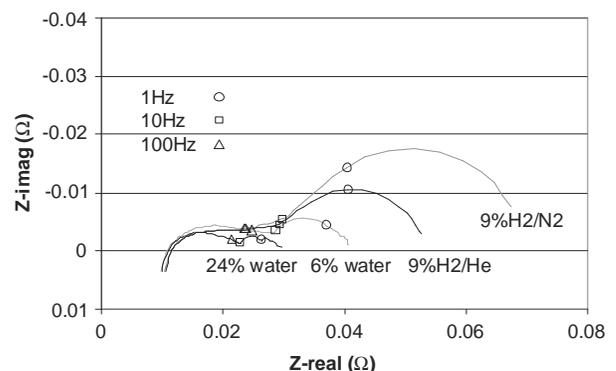

Figure 3 Impedance spectra of PC0030 obtained at 850 ^{o}C with various anode gas streams.