Analytical and FEM-Modelling of Cathode/Electrolyte Interfaces

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A Finite Element- (FEM) and an analytical model were developed describing the electrical performance of a three dimensional interface between cathode and electrolyte.

In order to develop a FEM- and a analytical model, the electrical properties of cathode, the interface and the electrolyte were examined. Taking into account the enlargement of the interface surface, electrical conductivity and electrode resistance R_η, the entire DC polarisation-resistance R_{pol} and the ohmic resistance could be calculated.

An enlargement of the electrochemical active surface leads to a significant increase of the electrical performance of a SOFC. The electrochemical active cathode-surface was increased by screen printing and sintering individual particles of 10YSZ (10YSZ: 10mol% Yttria stabilized Zirconia) onto an electrolyte substrate (8YSZ). By variation of the particle size and coverage of a electrolyte, different 10YSZ-structures have been realized on the substrate surface. Afterwards a nanometer-scale intermediate layer of substoichiometric LSM (LSM: $La_{0.75}Sr_{0.2}MnO_3$) was applied by MOD (Metal Organic Deposition) technique and finally, a screen printed LSM layer was applied as a current collector and gas distribution layer.

The electrical properties for different symmetrical cathode-halfcells have been evaluated, to describe the reaction of the interface cathode/electrolyte. A additional thin layer called CT-layer, which assume the electrode resistance R_η, was included into each model to characterize the electrical behaviour of the interface reaction. After requiring the electrical data, a one to one description of a cathode was implemented into the FEM- and the analytical model. Calculations with the FEM- and the analytical model have been carried out, to get the polarisation- and the ohmic resistance of a cathode.

Structured cathodes have been included into the FEM-model (see Fig.1). Calculations for different kind of topologies showed a good correlation (see Fig.2).

For the analytical model the polarisation- and the ohmic resistance was calculated for each specimen, by including the electrical conductivity of each layer and the geometrical data. The ohmic resistance of a unit cell was calculated without a CT-layer and the polarisation resistance by calculating the resistance of the CT-layer. The comparison between the measurements and the analytical model showed reasonable values of the ohmic and the polarisation resistance.

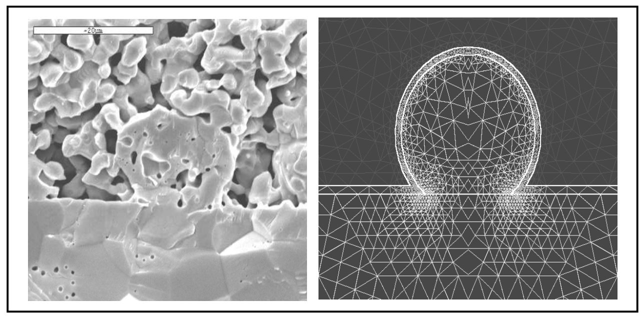

Fig.1: SEM-image (left) and FEM-image (right) of a three dimensional cathode/electrolyte interface.

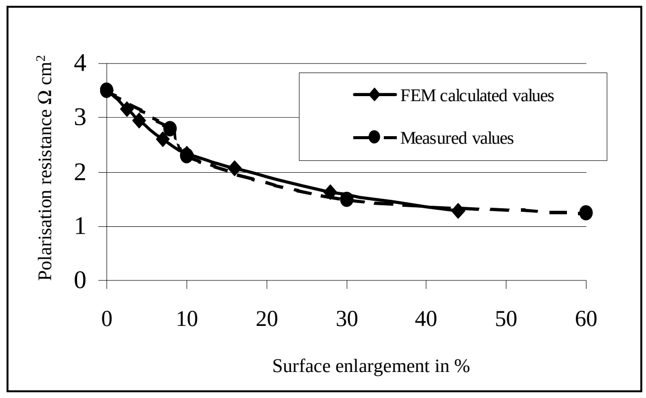

Fig.2: FEM-calculation and measured polarisation resistance for three dimensional cathode/electrolyte interfaces with different interface topologies.

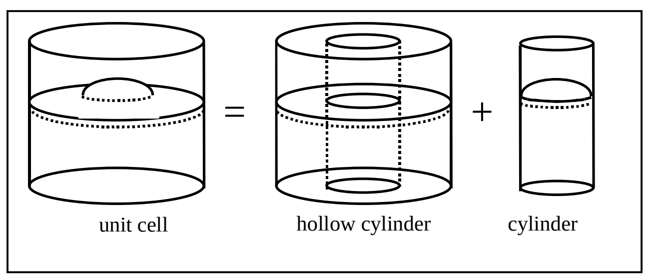

Fig.3: Analytical model: A unit cell was divided into a layered hollow cylinder and a solid cylinder.

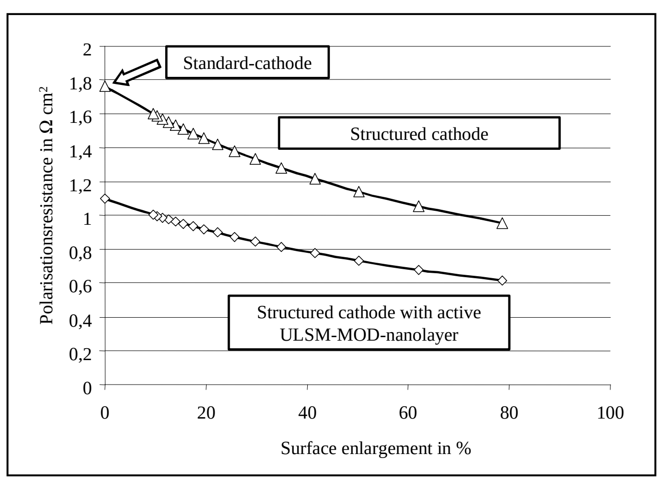

Fig.4: Polarisation resistance of different cathode/electrolyte interface topologies with and without a high active interface realized by ULSM-MOD-layer