

Verification of Control Theory Based Models for Dynamic SOFC Operation

Sven Schäfer¹, Klaus Schmid², Albert Krügel¹,
A. Weber¹, Ellen Ivers-Tiffée¹, Volker Krebs²
Universität Karlsruhe (TH)

¹Institut für Werkstoffe der Elektrotechnik,

¹Adenauerring 20, 76131 Karlsruhe, Germany

²Institut für Regelungs- und Steuerungssysteme,

²Kaiserstraße 12, 76131 Karlsruhe, Germany

During the startup (first electrical loading) of SOFC single cells a microstructural formation of cathode/electrolyte interface takes place. Fig. 1 shows the temporal course of the cell voltage and the corresponding anodic and cathodic polarizations. With increasing electrical load j , the cell voltage first decreases according to the internal resistance of the cell. Afterwards, a significant increase of the cell voltage at a constant current density takes place, which can be attributed to a decreased polarization resistance of the cathode.

Some of the microstructural changes leading to this decrease of the cathodic polarization are well known for several material systems (1). In (2,3), a dynamic model has been developed that simulates these changes for cells with $(La_{0.8-x}Sr_{0.2})MnO_3$ cathodes. The model contains internal parameters of the cathode that can not be measured directly in a real system. Fig. 2 shows the model prediction for the temporal course of two of these parameters during the activation.

It will be the purpose of this contribution to present an approach to verify the dynamic model by post-mortem microstructural investigations of single cells and impedance spectroscopy.

During the startup of single cells, the impedance was measured for different loads. The evaluation of the impedance spectra was performed with the Relax method (4). Fig. 3 shows the resulting distribution functions of relaxation times for different loads. Fig. 3 illustrates the relation between the level of formation and the changes in the spectra. Fig. 4 compares the distribution function before and after the startup for the same current density, which shows the effect of the activation on the cell performance.

The paper first introduces the investigated SOFC materials and their startup behaviour. The existing dynamic model will be explained. Emphasis will be placed on the verification methods. The relation between of internal model parameters by impedance spectroscopy and the distribution of relaxation times.

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2. Schmid et al., Proceedings of Materials Week 2001, CD-ROM (2001).
3. Schmid et al., in *MRS Symposium Proceedings*, I. Takeuchi et al., Editors, Combinatorial and Artificial Intelligence Methods in Materials Science, p. 265, MRS Symposium Proceedings Volume 700, Boston (2001).
4. Schichlein et al., in *SOFC VII*, S.C. Singhal., Editors, p. 564 Electrochem. Society Proc. Series, Pennington, NJ (2001).

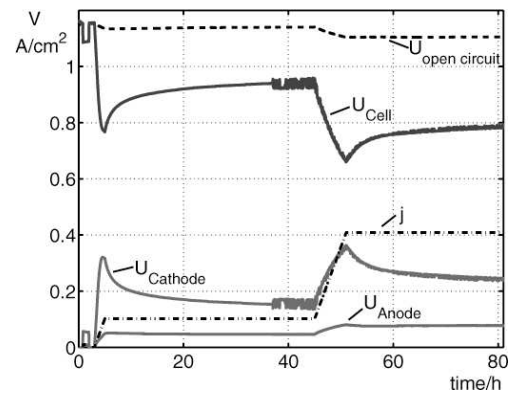


Fig 1: Activation of a single cell.

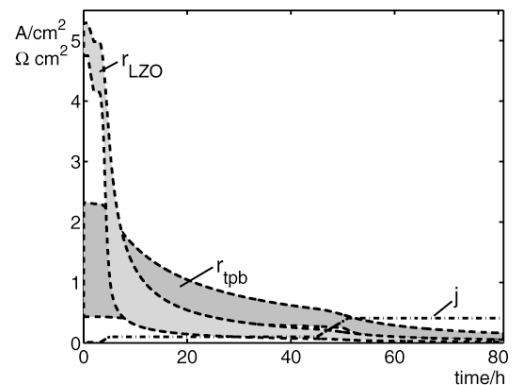


Fig 2: Simulation of the internal – not measurable – resistances.

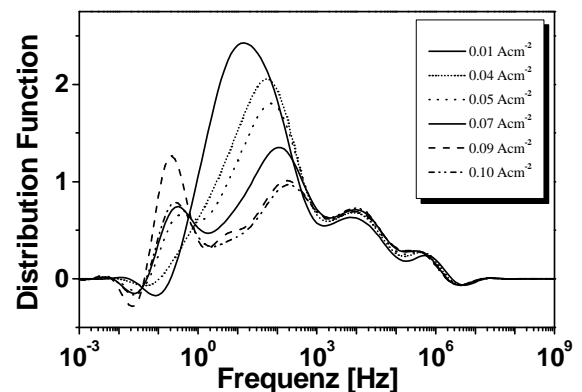


Fig 3: Distribution Function of Relaxation Times for different load steps during startup.

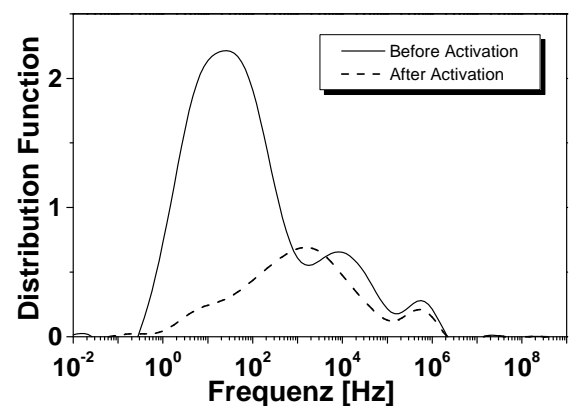


Fig 4: Distribution Function of Relaxation Times before and after the startup.