Physically-based deconvolution of impedance spectra for LSCFbased Solid Oxide Fuel Cells

Bertei[1], T. Ferrari[1]*, C. Nicolella[1], J.P. Ouweltjes[2], Z. Wuillemin[2], P. Piccardo

[1] Department of Civil and Industrial Engineering, University of Pisa, Largo Lucio Lazzarino 2, IT-56126 Pisa, Italy
[2] SOLIDpower S.A., Avenue des Sports 26, CH-1400, Yverdon-les-Bains, Switzerland
[3] Department of Chemistry and Industrial Chemistry, University of Genova, Via Dodecaneso 31, IT-16146 Genova, Italy
*toms.ferr@gmail.com

A physically-based model for the interpretation of the impedance spectra of an anode-supported LSCF/GDC/YSZ/Ni:YSZ solid oxide fuel cell is presented in this work. The model locally describes transport and reaction phenomena within the cell components through mass conservation equations. The microstructural properties of the electrodes are predicted through numerical three-dimensional reconstruction of the microstructure, with input parameters obtained from the analysis of SEM pictures of each layer. Simulations show that the model reproduces impedance spectra obtained in different operating conditions with the same set of fitting parameters, comprising material-specific kinetic constants and electrochemical capacitances, which fairly agree with independent literature data and a previous analysis of the spectra through DRT. The model allows for the deconvolution and quantification of the characteristic resistance and frequency of the different physical processes that build up the impedance of the cell. In particular, 7 processes are identified: charge-transfer reactions between LSCF/GDC, GDC/YSZ and Ni/YSZ interfaces appear in the high- frequency range, the medium-frequency feature is due the oxygen reduction reaction and the gas diffusion in the anode, while the low-frequency arc is mainly due to the gas conversion in the anodic channel. An additional low frequency contribution (< 1Hz), not considered in the model, is observed and tentatively attributed to the adsorption of oxygen onto the LSCF surface. Simulation results suggest that more efforts must be dedicated to characterize and improve the oxygen transfer at the LSCF/GDC and GDC/YSZ interfaces. The study shows that a quantitative interpretation of impedance spectra is possible with a reduced number of fitting parameters when a physically-based approach is adopted, making the model an attractive tool for diagnostic purposes

Keywords: SOFC, impedance, physically-based modeling, deconvolution, LSCF