

EIS characterization of $\text{La}_{0.31}\text{Sr}_{0.58}\text{Ti}_{0.97}\text{Ni}_{0.03}\text{O}_{3-d}$ thin film model SOFC electrodes

Mait Ainsar¹, Kuno Kooser², Margus Kodu², Glen Kelp², Gunnar Nurk¹

¹ *Institute of Chemistry, University of Tartu, Ravila 14a, 50411 Tartu/Estonia*

² *Institute of Physics, University of Tartu, W. Ostwaldi 1, 50411 Tartu/Estonia*
mait.ainsar@ut.ee

Mixed ionic electronic conducting solid oxide fuel cell anode materials with perovskite structure are promising because of their high performance at the lower end of SOFC operating temperature range (~600 °C). The material studied in this work, $\text{La}_{0.31}\text{Sr}_{0.58}\text{Ti}_{0.97}\text{Ni}_{0.03}\text{O}_{3-d}$ (LSTN) is a A-site deficient Sr-titanate, where Ni will be exsolved from the lattice upon reduction of the material, creating Ni nanoparticles on the surface and enhancing the electrochemical activity of hydrogen oxidation. In this work, thin film LSTN model electrodes are studied with electrochemical impedance spectroscopy (EIS) in three water-hydrogen concentrations (1.6%, 12% and 42% of H_2O by volume in mixture with H_2) at OCV and under anodic polarization up to + 0.4 V at 650 °C in two-electrode configuration, where counter electrode is highly active porous GDC-Pt [1]. The measurements were performed to complement NAP-XPS measurements performed at the same oxygen partial pressures with thin film LSTN model electrodes.

Impedance spectra of circular LSTN microelectrodes (0.15 -1.8 mm in diameter) had highly depressed shape uncommon when compared with other works using mixed ionic electronic conducting SOFC microelectrodes [2]. Distinct microelectrode size-dependent feature was observed in the high to medium frequency range appearing because of relatively high chemical capacitance to electronic conductivity ratio of the LSTN, the larger the electrode was the larger the in-plane electronic conductivity limitation was. For that reason low frequency region (1 – 0.01 Hz) of EIS spectra were used for fitting with $R_s(R_p\text{-CPE})$ circuit, where R_p described LSTN|gas surface electrochemical activity and Q of the constant phase element described bulk LSTN chemical capacitance. R_s was determined by the contact taken with microelectrode and was small compared to R_p . Polarization dependence showed a minimum of R_p at 0.3 V and increase in R_p upon further anodic polarization. The phenomena is explained by reoxidation of Ni exsolutives, causing sudden increase in polarization resistance and reversibly passivating the surface. The Q parameter returned to the same values (under polarization and at OCV) in the beginning and in the end of the measurement series, indicating stability of the bulk LSTN. Activation energy of R_p showed a decrease from 1.6 % H_2O to 12% H_2O , which matched with a drop in R_p .

Acknowledgements

This work was supported by Estonian Research Council grant PRG551 and by the project „Increasing the knowledge intensity of Ida-Viru entrepreneurship“ (ÕÜF2) co-funded by the European Union, and by Estonian Ministry of Education and Research (TK210). Part of the research was conducted using the NAMUR+ core facility supported by the Estonian Research Council (TT 13).

References

1. A. Nanning and J. Fleig, *Surface Science*, 2019, 680, 43–51.
2. F. S. Baumann, J. Maier and J. Fleig, *Solid State Ionics*, 2008, 179, 1198–1204.