Developmenet of novel fuel electrode for solid oxide cells with increased redox stability

S. Paydar[1,2*], I. Kivi[2], J. Aruväli[3], O. Volobujeva[4], G. Nurk [2]

[1]H2Electro OÜ, Lõõtsa 8, Ülemiste City, 11415 Tallinn, Estonia
[2] Institute of Chemistry, University of Tartu, Ravila 14a, Tartu 50411, Estonia
[3] Institute of Ecology and Earth Sciences, University of Tartu, Ravila 14a, Tartu 50411, Estonia
[4] Department of Materials Science, Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia
**sara.paydar@ut.ee*

State of the art commercial solid oxide cell systems are using traditional nickel-based anodes, which have high conductivity and excellent catalytic activity, however, they encounter significant challenges such as high sensitivity towards carbon deposition, sulfur poisoning, the moderate redox stability and Ni-coarsening of the Ni-based cermet[1]. Consequently, there exists a growing interest in the exploration of alternative materials to replace Ni-cermet fuel electrodes, aiming to eliminate the aforementioned drawbacks. $(La,Sr)TiO_{3-\delta}$ has attracted specific attention over the past years due to its superior chemical compatibility, high conductivity, and significant tolerance against sulfur poisoning and carbon depositions. To increase the catalytic activity and chemical stability, many different doping levels and stoichiometries for $La_xSr_{1-x}TiO_{3-\delta}$ (LST) have been investigated[2]. Based on literature data it could be proposed that additional doping of B-site of Ni -doped titanate with Cu might have positive effect on the carbon tolerance of electrode and possibly it also influences the electrical properties of material[3]. It has been demonstrated experimentally that A-site deficiency can enhance both electronic and ionic conductivity of $Ln_xSr_{1-x}TiO_{3-d}$ compounds[4]. Furthermore, A-site deficiency has also been used as a means to mitigate Sr segregation[5].

In this research influence of A-site deficiency and B-site chemical composition on electrical and electrochemical performance of $(La_{0.25}Sr_{0.25}Ca_{0.45})_yTi_{0.95}Ni_{0.05-x}Cu_xO_{3-\delta}$ ($0 < x < 0.05$, $1 < y < 0.947$) (referred to as 5LSCTNCu-x and 10LSCTNCu-x) hydrogen electrodes have been studied. X-ray diffraction has been used to characterize the crystallographic properties and SEM to visualize the surface microstructure of studied electrode layers. The X-ray diffraction (XRD) of the investigated electrode powders revealed a remarkable correlation between the lattice parameters and the B-site composition.

To understand the influence of MIEC material composition on electrical conductivities of LSCTNCu, the DC four-probe conductivity measurements of porous electrode layers have been performed. Conductivities have been measured at two different atmospheres: 1% H_2 + 1.7% H_2O + 97.3% Ar and 98.3% H_2 + 1.7% H_2O. It has been shown that all materials with LSCTNCu compositions behave like semiconductor and the conductivity is significantly dependent on composition. The highest electrical conductivities of porous electrode layers was observed for the LSCTNCu materials with 10% A-site deficiency, in 98.3% H_2 + 1.7% H_2O atmosphere. The electrochemical symmetric cell measurements (at 800 °C, in humidified H_2, during 100 hours) show that small stochiometric changes in B-site composition and A-site deficiency significantly influence the activity and initial degradation rate of the electrode.

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