



**Euroopa Liit
Euroopa Sotsiaalfond**



Eesti tuleviku heaks

**Toetab TÜ ja TTÜ doktorikool
“Funktsionaalsed materjalid ja tehnoloogiad” (FMTDK)**

ESF projekt 1.2.0401.09-0079

ANALYSIS OF PROCESSES IN SOLID OXIDE FUEL CELLS BASED ON THE POROUS CATHODES AND ANODES

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Solid oxide fuel cells (SOFCs) are very promising chemical energy conversion systems for cogeneration of electricity and heat. Lowering the operating temperature is the main challenge in current SOFC research activities. Such a reduction would greatly enhance the long-term stability of the fuel cell, widen the construction material selection lessen the sealing problem, and thus decrease the cost of SOFC technology. Nowadays the intermediate temperature SOFCs operating at $773 < T < 973$ K, based on doped ceria electrolytes with yttria stabilized protective electrolyte layer at the anode side, are seen as a viable alternative for yttria stabilized zirconia based electrolyte systems. We believe that activated lanthanide cobaltite based micro-meso-macro- porous $\text{La}_{0.4}\text{Sr}_{0.6}\text{CoO}_{3-\delta}$, $\text{Pr}_{0.4}\text{Sr}_{0.6}\text{CoO}_{3-\delta}$, and $\text{Gd}_{0.4}\text{Sr}_{0.6}\text{CoO}_{3-\delta}$ cathodes, prepared from corresponding nanopowders, are the probable cathodes for the intermediate temperature SOFC [2-4]. For future decrease of the working temperature, the more active micro-mesoporous cathodes and anodes are inevitable.

The micro-meso-macro-porous $\text{La}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$, $\text{Pr}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$ and $\text{Gd}_{1-x}\text{Sr}_x\text{CoO}_{3-\delta}$ cathodes have been synthesized by using the nitrate solution thermal decomposition method and characterized by N_2 and Ar sorption (BET), X-ray diffraction, SEM, AFM, cyclic voltammetry, chronoamperometry and electrochemical impedance methods [2-4]. The micro-meso-macro-porous $\text{Ni-Ce}_x\text{Gd}_{1-x}\text{O}_{2-\delta}$ and $\text{Ni-Zr}_x\text{Y}_{1-x}\text{O}_{2-\delta}$ anodes have been prepared using raw nanopowders with S_{BET} equal to 6.3, 70.75 and $135 \text{ m}^2 \text{ g}^{-1}$ (NexTech Materials). For the detailed material analysis, the three electrode setup was used. The cathodes and anodes were deposited onto the electrolyte by screen-printing, followed by sintering at 1350°C for the anode and longlasting sintering at 1150°C for the cathode. To increase the macroporosity of the cathode and the anode, the additional pore forming agent (PFA) was added into the raw electrode paste.

The contribution of cathode to the overall twoelectrode cell response has found to be important on the basis of differential derivative ($\Delta\partial Z$ vs. $\log f$) plots method by varying chemical composition and oxidant pressure (from 0.21 to 1 atm) [2-4]. The oxygen electroreduction process was found to be strongly dependent on the external potential applied to the cell as well as P_{O_2} , indicating slow charge transfer process limitation at $T > 873$ K. At lower temperatures the mass transfer process inside porous cathode influences noticeably the reaction rate. It was found that the operation of the single-cells is not limited by slow cathodic processes only, and the anodic processes also contribute to the total polarization resistance of the single-cells. The latter result was confirmed by the influence of fuel composition variation on the area-specific series polarization resistance values of the single-cells at $P_{\text{O}_2} = \text{const.}$ and $T = \text{const.}$ It was found that the total polarization resistance depends noticeably on the specific surface area of the NiO , $\text{Ce}_{1-x}\text{Gd}_x\text{O}_{2-\delta}$ and $\text{Zr}_{1-x}\text{Y}_x\text{O}_{2-\delta}$ raw powders used for preparation of the anode functional layers.

Acknowledgements: This work was supported by AS Elcogen and ESF Grant No. 7791.

References

1. B.C.H. Steele, *Solid State Ionics* 129 (2000) p. 95-110.
2. I. Kivi, P. Möller, S. Kallip, G. Nurk, E. Lust, *Electrochem. Commun.* 10 (2008) 1455.
3. R. Küngas, I. Kivi, E. Lust, *J. Electrochem. Soc.* 156 (2009) B345.
4. R. Küngas, I. Kivi, K. Lust, G. Nurk, E. Lust, *J. Electroanal. Chem.* 630 (2009) 94.