PHYSICO-CHEMICAL PROPERTIES OF LANTHANUM COMPOUNDS AS CATHODE MATERIALS FOR SOLID OXIDE FUEL CELLS

Guseva E.M.[1], Kolchugin A.A.[2], Ivanov R.A.[1], Filonova E.A.[1]
[1)] Ural Federal University, Yekaterinburg, Russian Federation
[2)] Institute of High-Temperature Electrochemistry, Yekaterinburg, Russian Federation
E-mail: katigusewa@yandex.ru

Calculations of the configurational entropy, fixation factors, crystal structure and electrochemical performance study of the perovskite-type and Ruddlesden-Popper phases on the base of the lanthanum and 3d-transition metal oxides are performed.

The active search for materials for solid oxide fuel cell (SOFC) cathodes involves the tasks of synthesis, phase, structural and electrochemical characterization of promising complex oxides with mixed electron-ion conductivity, such as Ruddlesden-Popper phase $La_2NiO_{4+\delta}$ [1,2] and perovskite $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ [3]. The optimal substitution on A- and B-sublattices using, for example, the medium- and high-entropy doping strategy [4] can be the adequate solution of the problems of chemical and mechanical-thermal compatibility with electrolytes and a high overvoltage at the cathode-electrolyte interface.

The $La_{2-x}Sm_xNiO_{4+\delta}$ (LSNO) and $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.7-y}Mn_yNi_{0.1}O_{3-\delta}$ (LSCFMN) samples were synthesized by the citrate-nitrate combustion method. The phase and structure characterization was performed by powder X-ray diffraction in air, the crystal structure parameters were refined by a Rietveld full-profile method. The electrochemical activity of the obtained cathodes was studied using the impedance spectroscopy on the symmetrical cells with a $Ce_{0.8}Sm_{0.2}O_{1.9}$ (SDC) electrolyte.

The configurational entropy calculations for the considered complex oxides have indicated that the LSCFMN series has the values of Sconf in the range of $1.09 \leq S_{conf} \leq 1.30$, LSNO has the values of S_{conf} in the range of $0.32 \leq S_{conf} \leq 0.67$. Thus, LSCFMN can be considered as medium-entropy materials, LSNO as the low-entropy materials. Calculations of the stability factor of the medium-entropy material LSCFMN, have demonstrated, that all LSCFMN oxides satisfied the requirements up to the maximum value of 6 %.

The LSNO samples have a tetragonal structure (I4/mmm); the LSCFMN samples have a rhombohedral structure (R-3c). Concentration dependences of the cell parameters in the LSNO series show that with increasing samarium content a decrease in all calculated parameters was observed, which is explained by the size effect. The cell parameters of LSFMN do not show the obvious correlation with the manganese content. By measuring the electrochemical activity of LSNO with a collector layer on the SDC electrolyte substrate, the polarization resistance R_p values, obtained at 700 °C were 0.954; 0.860 and 1.212 Ω cm^2 for x =0.2; 0.4; 0.6 respectively. However, these values were higher than the R_p value for the base LSCF cathode (0.22 Ω cm^2 at 700 °C),

suggesting that LSNO can be considered as cathodes for intermediate-temperature SOFCs, but further studies are needed to reduce the R_p value.

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