

Supplementary Information

# Densification and Proton Conductivity of $\text{La}_{1-x}\text{Ba}_x\text{ScO}_{3-\delta}$ Electrolyte Membranes

Alyona Lesnichyova <sup>1,2</sup>, Semyon Belyakov <sup>3</sup>, Anna Stroeva <sup>4</sup>, Sofia Petrova <sup>5</sup>, Vasily Kaichev <sup>6</sup> and Anton Kuzmin <sup>1,4,\*</sup>

<sup>1</sup> Laboratory of Solid-State Chemistry, Institute of Solid-State Chemistry and Mechanochemistry SB RAS, Novosibirsk 630128, Russia

<sup>2</sup> NANOTECH Centre, Ural Federal University, Yekaterinburg 620075, Russia

<sup>3</sup> Laboratory of Electrochemical Materials Science, Institute of High-Temperature Electrochemistry UB RAS, Yekaterinburg 620137, Russia

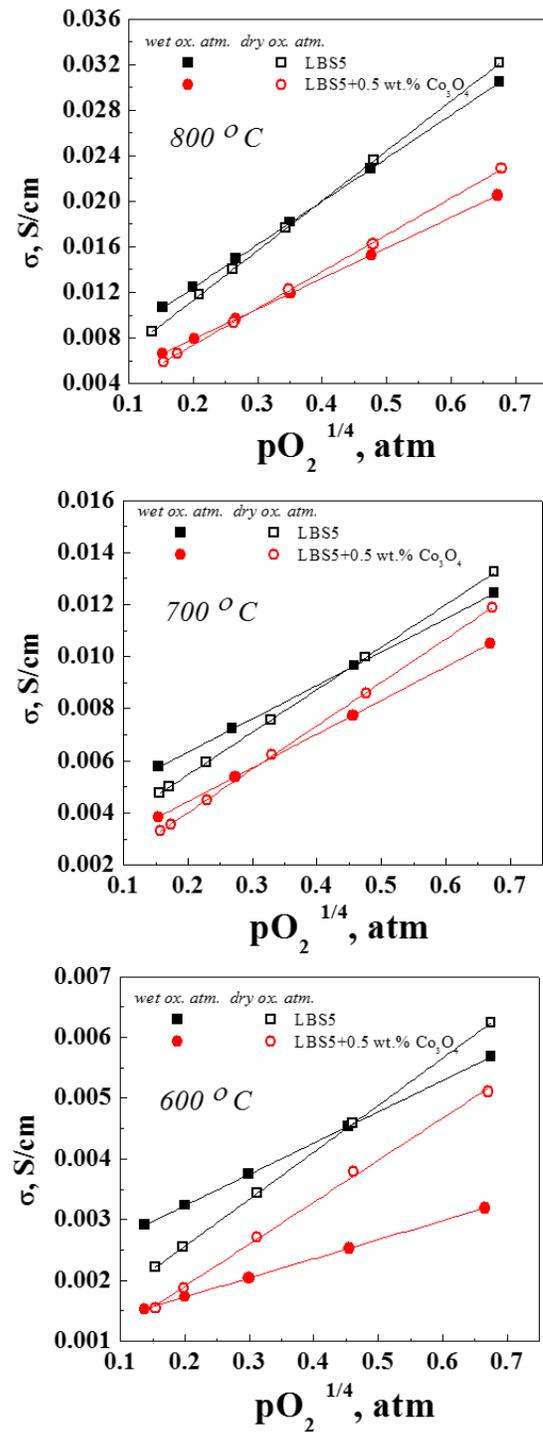
<sup>4</sup> Department of Technology of Inorganic Materials and Electrochemical Production, Vyatka State University, Kirov 610000, Russia

<sup>5</sup> Laboratory of High-Entropy Alloys, Institute of Metallurgy UB RAS, Yekaterinburg 620016, Russia

<sup>6</sup> Department of Catalysis Research, Boreskov Institute of Catalysis SB RAS, Novosibirsk 630090, Russia

\* Correspondence: a.v.kuzmin@yandex.ru

**$p\text{O}_2$  – dependencies of conductivity**

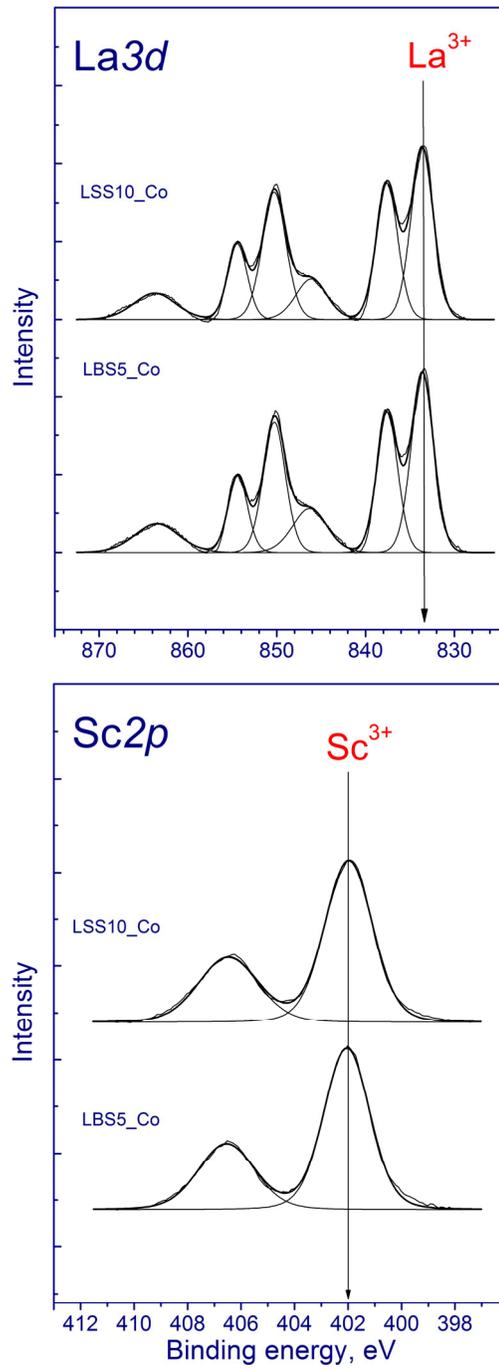


**Figure S1.** Conductivity of ceramics as a function of  $(pO_2)^{1/4}$  under wet ( $pH_2O = 2.8$  kPa) and dry ( $pH_2O = 0.1$  kPa) conditions.

### XPS analysis

The La3d level splits into two sublevels as a result of the spin-orbit interaction, which leads to the appearance of a doublet La3d<sub>5/2</sub> - La3d<sub>3/2</sub> (~16.8 eV). Each La<sup>3+</sup> component in the La3d spectra is accompanied by intense 'shake-up' lines of the satellites. The main La3d<sub>5/2</sub> peak for La<sub>2</sub>O<sub>3</sub> is located in the region of 833.2-834.0 eV. For lanthanum carbonate La<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>, slightly higher binding energies of La3d<sub>5/2</sub> are observed in the range of 835.0-835.5 eV, and for lanthanum hydroxides LaOOH and La(OH)<sub>3</sub> it is about 834.8 eV. In our case, La<sup>3+</sup> is in the form of La<sub>2</sub>O<sub>3</sub> or LaSrO<sub>x</sub>.

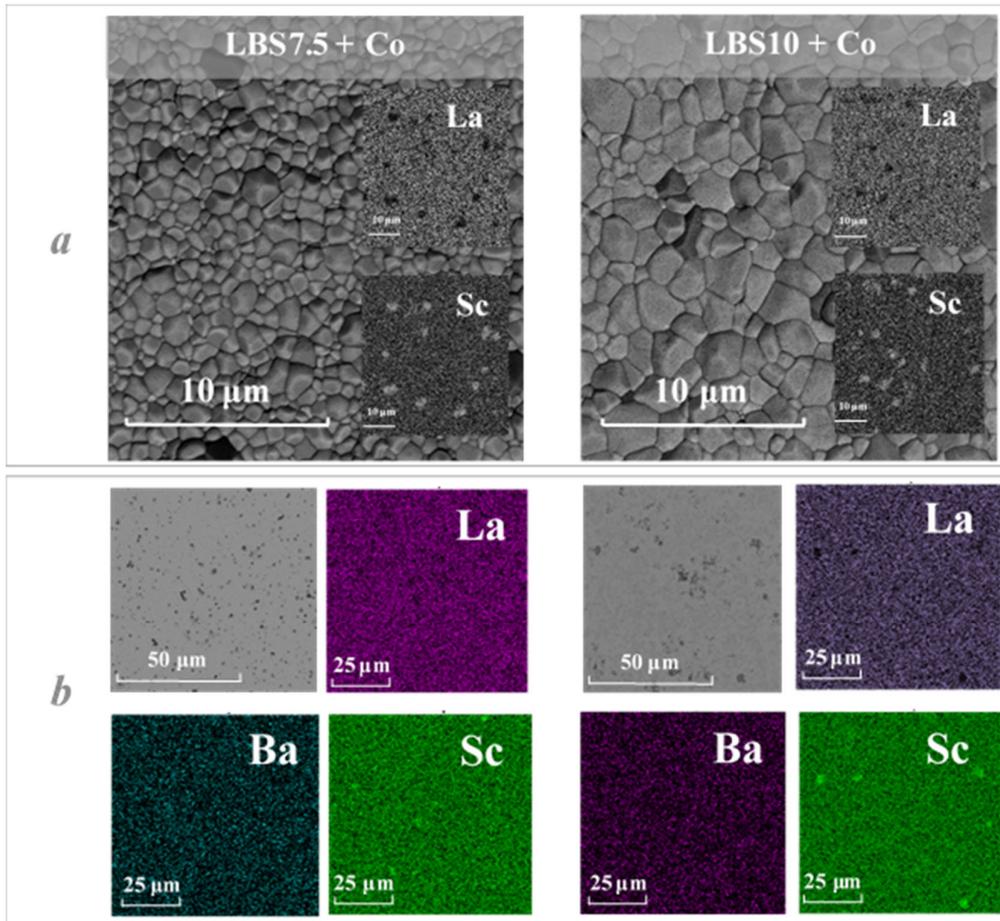
The Sc2p level splits into two sublevels Sc2p<sub>3/2</sub> and Sc2p<sub>1/2</sub> (4.46 eV) due to the spin-orbit interaction. In the literature, the binding energy values of Sc2p<sub>3/2</sub> for Sc<sup>3+</sup> are given in the range 401.7-402.5 eV, and in ScOOH it is 403.0 eV. The Sc2p spectra are described by a single doublet with a Sc2p<sub>3/2</sub> binding energy 402.0 eV (taking into account the correction of the binding energy by +1.9 eV). Thus, Sc<sup>3+</sup> is in the form of Sc<sub>2</sub>O<sub>3</sub> or ScSrO<sub>x</sub>.



**Figure S2.** La3d and Sc2p core-level spectra La<sub>0.95</sub>Ba<sub>0.05</sub>ScO<sub>3-δ</sub> + 0.5 wt% Co<sub>3</sub>O<sub>4</sub> and La<sub>0.9</sub>Sr<sub>0.1</sub>ScO<sub>3-δ</sub> + 0.5 wt% Co<sub>3</sub>O<sub>4</sub> samples.

**Phase equilibria (Ba-Co)**

The Sc-enriched phase is formed predominantly on the surface of ceramic samples, while its concentration in the bulk of the samples is low.



**Figure S3.** SEM-images of the surface (a) and cross-sections (b) of  $\text{La}_{0.925}\text{Ba}_{0.075}\text{ScO}_{3-\delta} + 0.5 \text{ wt\% Co}_3\text{O}_4$  and  $\text{La}_{0.9}\text{Ba}_{0.1}\text{ScO}_{3-\delta} + 0.5 \text{ wt\% Co}_3\text{O}_4$  ceramics with EDX maps of cations distribution.