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Synthesis and Microstructural Study on Lanthanum Chromite-Based Ceramics

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Abstract – Lanthanum chromite-based ceramics are the main materials used as solid oxide fuel cell interconnects. However, there are several difficulties involved in the processing of these materials. In this work, we report a study on the microstructural characterization of the $La_{0.90}Ca_{0.05}Sr_{0.05}Cr_{0.95}Mg_{0.05}O_3$ (LCSCM) ceramic system (mol%) obtained by auto-ignition urea-based combustion process (UCP) and traditional ceramic method (CM, mixture of oxides). In general, obtained results corroborate the literature on the difficulty of densification of $LaCrO_3$-based systems, being that 97.1% was the biggest value reached for the densification degree, and in lower temperature conditions than those normally considered for pure or mono-doped lanthanum chromites.

Perovskite (ABO_3-type) lanthanum chromite ($LaCrO_3$) and especially doped $LaCrO_3$-based ceramics have recently received much interest as high-temperature electrode materials and solid oxide fuel cell (SOFC) interconnects, because they are p-type electronic conductor in oxidizing conditions and is stable to low oxygen partial pressures [1]. Nevertheless, the conductivity of pure lanthanum chromite is not sufficiently high for use as an interconnect material, but can be increased through doping. The electronic conductivity of the stoichiometric $LaCrO_3$ compound is increased by substituting divalent metal ions on either the A- or B-sites of the ABO_3 perovskite lattice. Thus, the sinterability and the electrical conductivity of $LaCrO_3$ could be improved by the substitution of a lower-valent ion such as Cu^{2+} or Mg^{2+} at the Cr^{3+} site or of Sr^{2+} at the La^{3+} site [2].

Powders of LCSCM lanthanum chromite composition were synthesized by solid-state reaction (auto-ignition) method (combustion method with urea as fuel) from the corresponding metallic nitrates and by traditional ceramic method from respective oxides, in both the cases using P. A. grade reagents. The final ball-milled powders were dry cold isostatic pressed at 200 MPa into pellets and sinterings were carried out in air at 1450^0C (at a constant heating rate of 5^0C/min) for sintering times between 2 and 6 hours. Microstructural characterization was effected by scanning electronic microscopy (SEM).

Figure 1 shows SEM powder images, which show that the CM synthesized powder is slightly larger than the UCP prepared powder, although in both cases it is note the tendency to formation of clusters or aggregated powder particles. Based on images showed in the Figure 2 it is possible to note that the LCSCM/UCP sample is more densified than LCSCM/CM sample. In fact, it appears that the grain growth appeared perfectly straight along the boundary, and clear grain boundary was observed. This feature of the microstructure usually appears in the dense sintered body. These microstructural results are reflected on the electrical and dimensional characteristics and the electrical conductivity values are in the range characteristic of lanthanum chromites mono- and dual-doped and also presents great variability [3].

In conclusion, it was verified that the urea-based combustion process from metallic nitrates was more efficient for the production of multiple doped lanthanum chromite-based ceramics than the traditional ceramic method, resulting in a microstructure characterized by more homogeneous grain size distribution. Thus, it was verified that $La_{0.90}Ca_{0.05}Sr_{0.05}Cr_{0.95}Mg_{0.05}O_3$ ceramics can be considered potential candidates for application in solid oxide fuel cell interconnects.

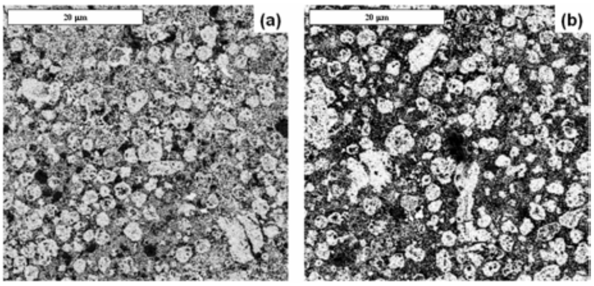

Figure 1: SEM photomicrographs of the calcined LCSCM powders obtained by: (a) combustion method (UCP); (b) mixture of oxides (CM).

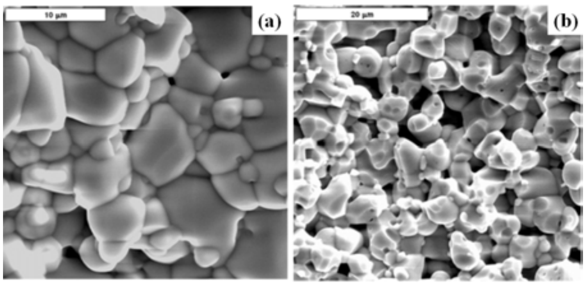

Figure 2: SEM photomicrographs of the best densified LCSCM ceramic systems which powder was obtained by: (a) combustion method (UCP), sintered (1450^0C/4h); (b) mixture of oxides (CM), sintered (1450^0C/5h).

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