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Performance of nanostructured perovskite-type cathodes for IT-SOFCs

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Abstract – We studied the performance of nanostructured cathodes for IT-SOFCs based on perovskite-type mixed ionic/electronic conductors. Different compounds and synthesis methods were evaluated. We found an excellent performance, which enhanced with decreasing grain size. This can be attributed to high specific surface area of these nanostructured cathodes, thus increasing dramatically the number of active sites for the oxygen reduction reaction.

Nanostructured materials attract great interest due to their novel properties. They have already been used in power generation and storage devices, such as lithium-ion batteries, low-temperature fuel cells, etc. [1]. These materials are not employed in conventional solid-oxide fuel cells (SOFCs) since grain growth is expected to occur at the typical operation temperatures of these devices. However, their use in intermediate-temperature SOFCs (IT-SOFCs) is currently under evaluation since grain growth can be minimized at this operation temperature range. For example, in a recent work carried out at our research group, we presented a new type of highly porous nanostructured cathodes which exhibit very low polarization resistance, prepared from $La_{0.6}Sr_{0.4}CoO_3$ nanotubes [2].

In this work, we present new studies on the performance of nanostructured cathodes for IT-SOFCs based on perovskite-type mixed ionic/electronic conductors (MIECs). We evaluated different compound and synthesis routes:

(i) $La_{0,6}Sr_{0,4}CoO_{3-x}$ (LSC), $Sm_{0,5}Sr_{0,5}CoO_{3-x}$ (SSC) and $Ba_{0,5}Sr_{0,5}Co_{0,8}Fe_{0,2}O_{3-x}$ (BSCF) nanopowders synthesized by citrate complexation and freeze-drying routes.
(ii) LSC nanotubes synthesized by the pore wetting technique using commercial polycarbonate membranes [2,3].

These nanomaterials were used to prepare pastes with organic vehicles and deposited on Gd_2O_3-doped CeO_2 (GDC) or Sm_2O_3-doped CeO_2 (SDC) electrolytes. In order to retain the original nanostructures in the final cathodes, both conventional thermal treatments at moderate temperatures and fast-firing processes under different conditions were used to attach them to the electrolyte. The area-specific resistance (ASR) of these nanostructured cathodes was evaluated by electrochemical impedance spectroscopy (EIS) on symmetrical [cathode/electrolyte/cathode] cells, measured in air.

Our results showed that the proposed nanostructured cathodes exhibit high performance, which enhances significantly with decreasing grain size. Very low ASR values for all compounds, in the range of 0.02-0.05 $\Omega.cm^2$ for an operating temperature of 700°C, were reached. Since, in the case of MIECs, the oxygen reduction reaction takes place in the entire surface of the cathode, this excellent performance can be attributed to the high specific surface area of the nanostructured cathodes. In this way, the number of active sites was dramatically increased.

References

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