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Strategies to obtain efficient symmetrical electrodes for solid oxide cells

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There is an increase interest on finding alternative energy technologies that can cope with the current energy demand while mitigating the climate change. Among those technologies, Solid Oxide Cells (SOCs) are promising electrochemical devices that can efficiently convert fuels (e.g. hydrogen, methane) into electricity under fuel mode, as well as producing fuels from water and CO_2 under electrolysis mode. In order to improve the durability of these devices, a new concept of symmetrical SOCs have been developed, where the same electrode material is used as both air and fuel electrode[1]. However, the main challenge of symmetrical electrodes is that they need to operate efficiently under both oxidizing and reducing atmospheres.

There are several strategies to synthesize high-performing symmetrical electrodes. In this work, we study three of them: i) preparation of novel materials based on Ti-doped $Sr_{0.95}FeO_{3-\delta}$ (SFT) and layered $Pr_{0.5}Ba_{0.5}FeO_3$ (PBF) perovskites; ii) exsolution of Ni nanoparticles in Ni-doped PBF; and iii) tailoring of the electrode/electrolyte interface with a nanocomposite active layer[2]. With that purpose, the electrode powders are prepared by the freeze-drying precursor method and screen-printed onto $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_{2.85}$ (LSGM) electrolyte, while the nanocomposite active layer is deposited in one-step by the spray-pyrolysis technique onto the electrolyte. A thorough characterization of the materials is performed regarding their crystal structure, microstructure and electrochemical properties.

XRD patterns confirm phase formation and redox stability under both air and 5% H_2 atmospheres for all synthesized materials. Fig. 1A shows a cross-sectional SEM image of the SFT-CGO electrode with an active layer at the electrode/electrolyte interface, consisting of an intimate mixture of two phases with nanometric grain size (Fig. 1B). Impedance data (Fig. 1C) indicate a lower polarization resistance of the electrode with the incorporation of the active layer: 0.23 Ω cm^2 over 0.42 Ω cm^2 with no active layer. This difference was less significant under H_2 atmosphere. As for $PBFN_x$, the exsolution of Ni particles on the electrode surface led to lower polarization resistances under reducing atmosphere: 0.23 Ω cm^2 over 0.52 Ω cm^2 for PBF at 650 ºC (data not shown). These findings prove that strategies to optimize the electrode composition and microstructure are key to develop efficient symmetrical SOCs.

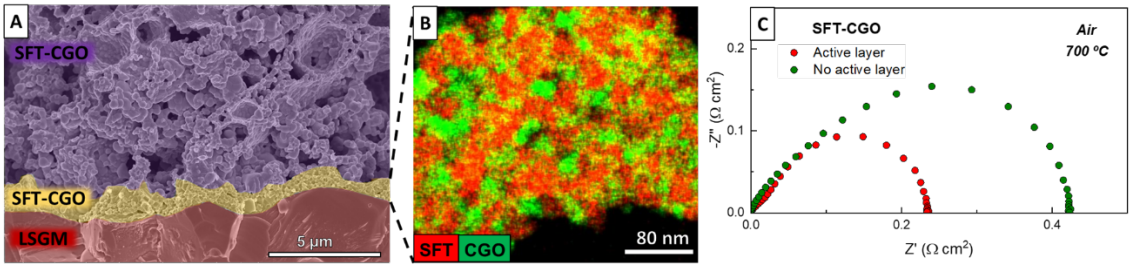

Figure 1. A) Cross-sectional SEM image of the electrode-electrolyte; B) TEM image of the nanocomposite active layer; C) Polarization resistances of the SFT-CGO electrode with and without the active layer in air at 700 ºC.

References

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