The Effects of Spray Pyrolysis Deposition and Ag Nanoparticles on the Electrochemical Performance of $Nd_{1/3}Sr_{2/3}CoO_{3-\delta}$:CGO Composite SOFC Cathodes

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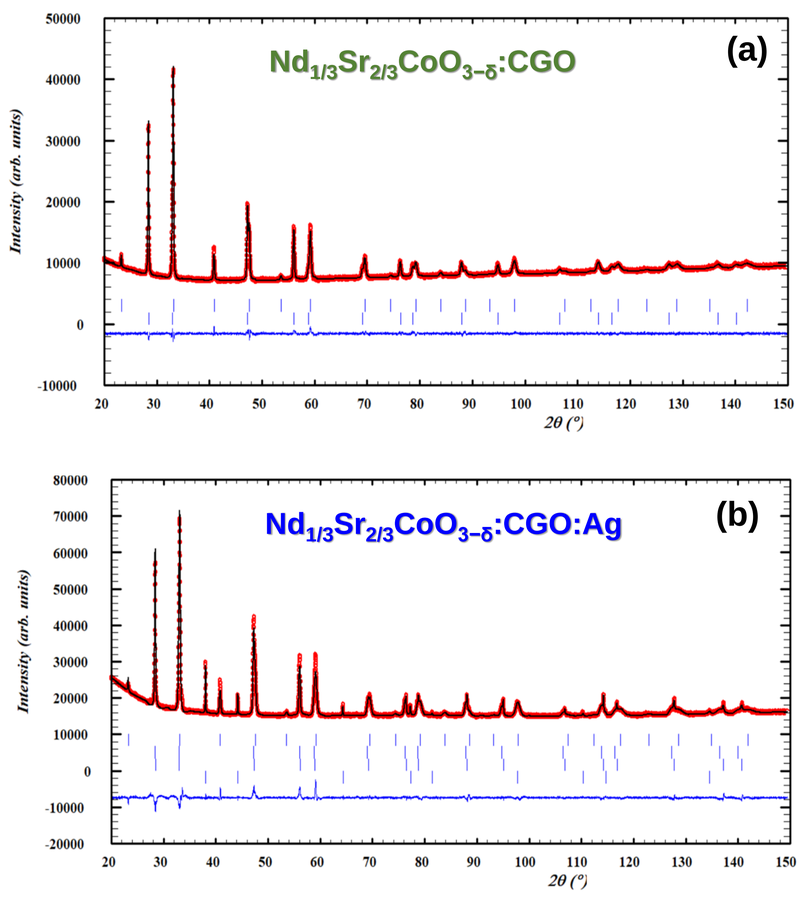
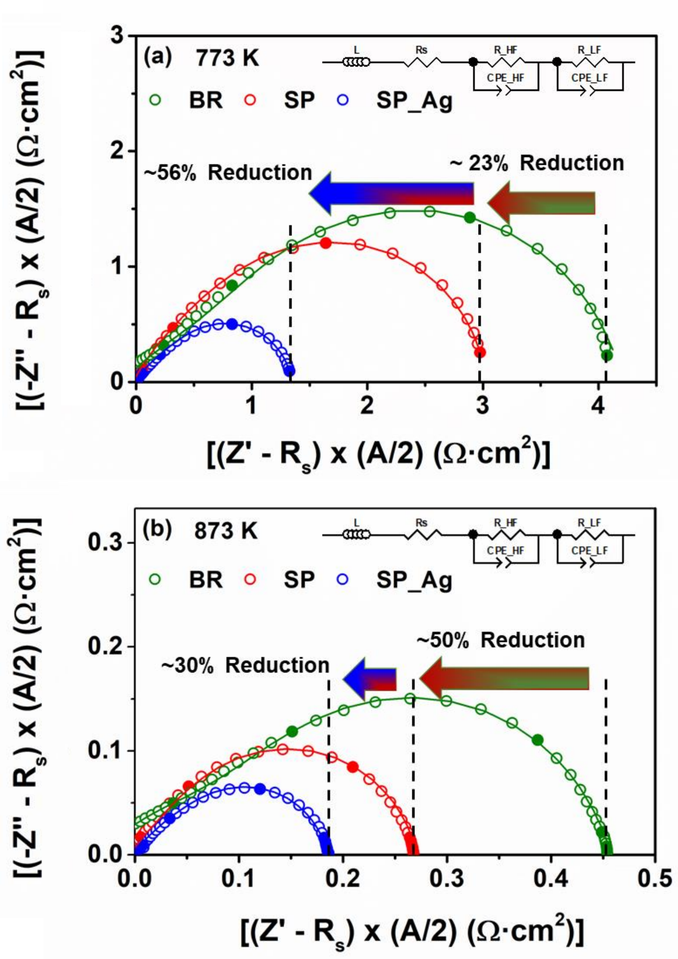
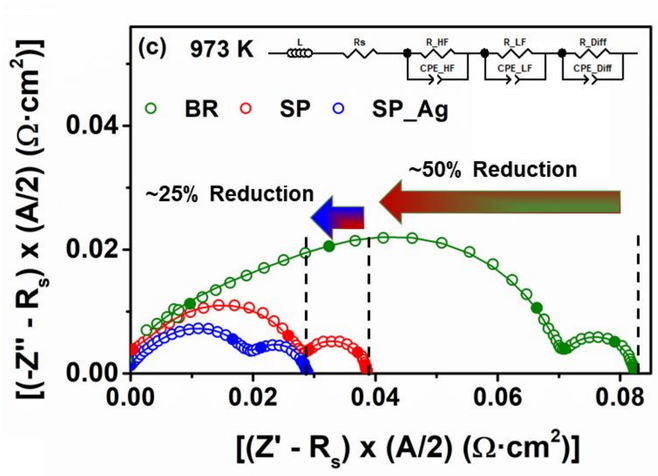
Crystal Structure – XRD



Experimental (red points), calculated (solid black line) and difference (blue line at bottom) XRD patterns at RT for $Nd_{1/3}Sr_{2/3}CoO_{3-\delta}$:CGO (a) and $Nd_{1/3}Sr_{2/3}CoO_{3-\delta}$:CGO:Ag (b); vertical bars indicate the expected position of Bragg peaks.

Electrochemical analysis





Comparison of impedance spectra of symmetrical cells with the composite cathodes over CGO electrolyte at 773 K (a), 873 K (b), and 973 K (c). Solid lines represent the calculated spectra using each equivalent circuit.

Summary

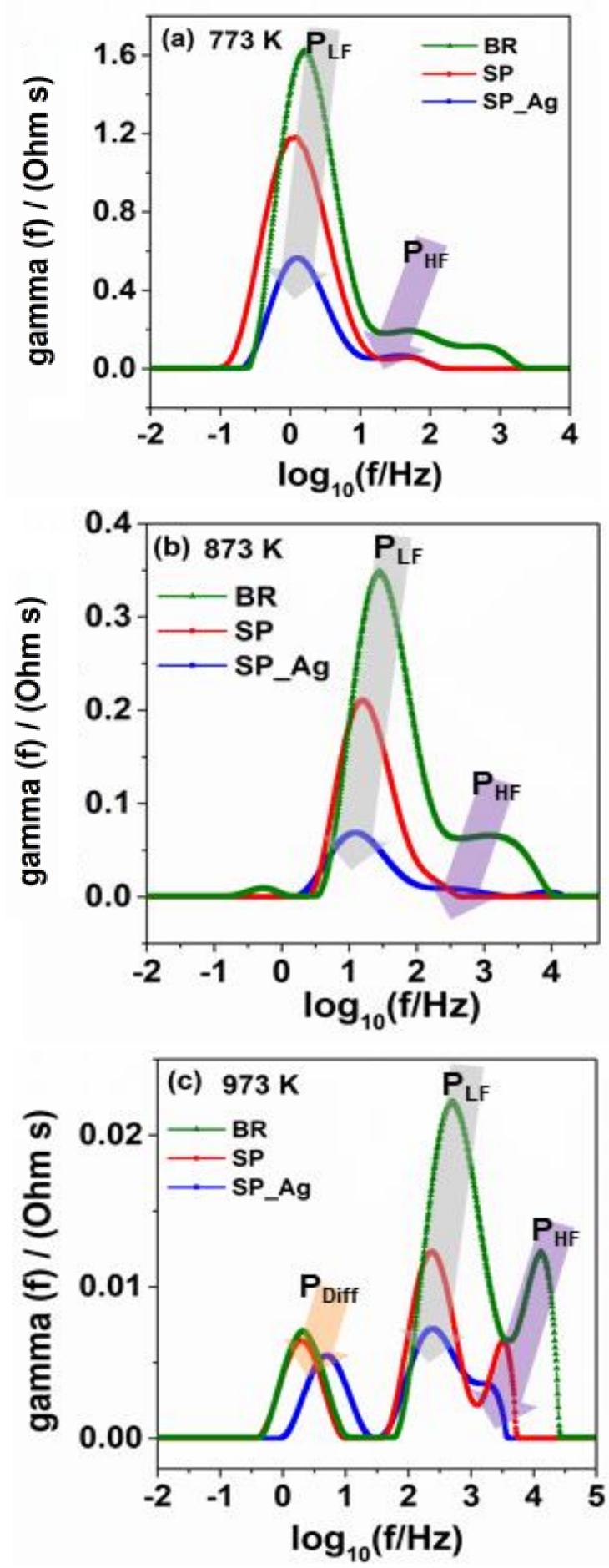
Electrochemical performances are compared between brush deposition (referred to as BR) and a single-step deposition by a cost-effective and scalable spray-pyrolysis (SP) on $Nd_{1/3}Sr_{2/3}CoO_{3-\delta}$:CGO composite SOFC cathodes. In addition, the impact of Ag nanoparticles (named in the text as SP_Ag) on the electrochemical behaviour of the SP cathodes was studied.

The overall polarisation resistances are closely related to the deposition method used, as well as the introduction of the Ag nanoparticles; however, both effects change with the temperature. The R_p of BR, SP and SP-Ag composites are 4.08, 3.07 and 1.35 Ω·cm², respectively at 773K. The impact of spray pyrolysis deposition on the R_p values remains at higher temperature, while the effect of the Ag nanoparticles diminishes. The R_p of BR, SP and SP-Ag are 0.08, 0.04 and 0.03 Ω·cm², respectively, at 973 K.

The resistance of the HF process is much lower for electrodes prepared by spray-pyrolysis deposition. This behaviour could be explained by the smaller particle size of the SP electrodes and reduced synthesis temperature, both of which improve charge transfer at the electrode/electrolyte interface and limit cation interdiffusion between the components. The Ag nanoparticles improve the electrochemical behaviour of the LF response at lower temperatures in comparison to the other composite electrodes, which may be attributable to better catalytic activity for the oxygen reduction reaction.

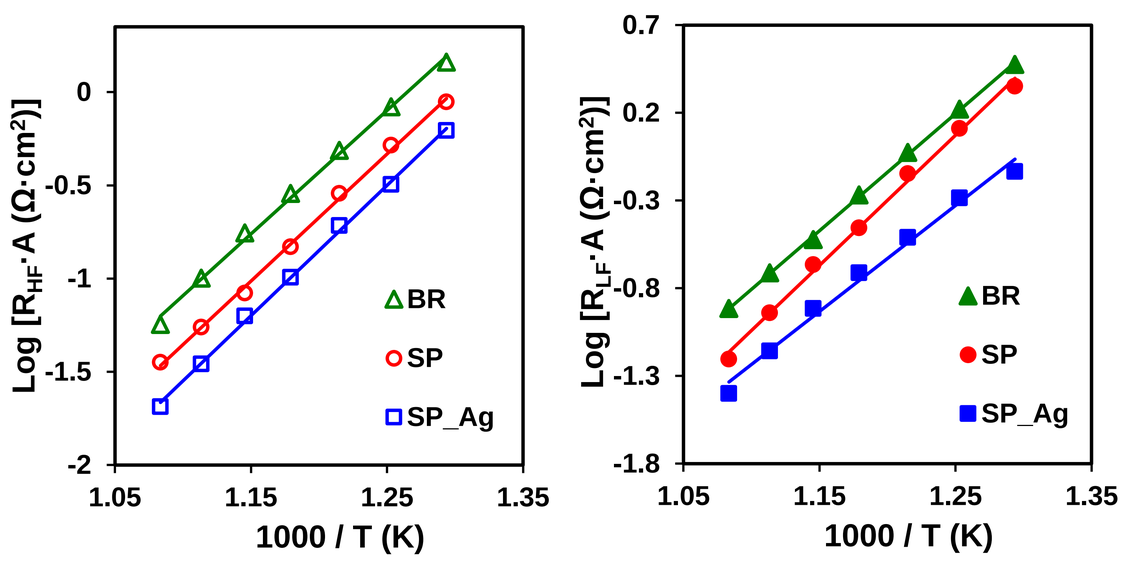
Distribution of relaxation times (DRT) verify that the electrochemical behaviour of the electrode involves two main contributions, related to charge-transfer at the electrolyte/electrodes interface at high frequency (P_{HF}) and to oxygen absorption/desorption associated with the reduction/oxidation reaction at low frequency (P_{LF}). As in the impedance spectra, a small process (P_{diff}) due to gas diffusion limitations into the electrode was identified at very low frequency at high temperature.

Distribution of Relaxation Times



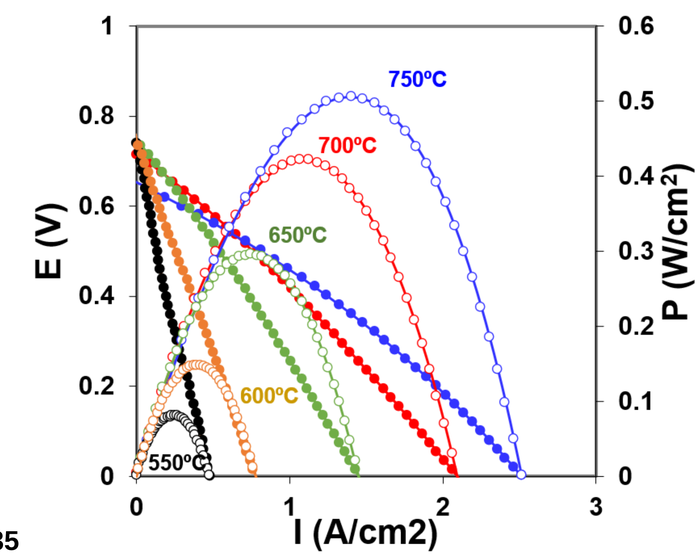
DRTs of IS spectra measured in air for symmetrical cells of all composites at 773 K (a), 873 K (b), and 973 K (c).

Electrode polarization resistance



Temperature dependence of electrochemical resistance associated with the high-frequency (a) and low-frequency (b) processes of the impedance spectra for the composite cathodes on CGO electrolyte.

Fuel Cell Performance



Fuel cell performance of the $Nd_{1/3}Sr_{2/3}CoO_{3-\delta}$:CGO:Ag cathode over a CGO electrolyte and Ni-CGO anode in the range 550–750 °C

Acknowledgements

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