Cathodes for Solid Oxide Fuel Cells Operating at Low Temperatures

This dissertation focuses on the development of nanostructured cathodes for solid oxide fuel cells (SOFCs) and their performance at low operating temperatures. Cathodes were mainly fabricated by the infiltration method, whereby electrocatalysts are introduced onto porous, ionic conducting backbones. High performance cathodes were obtained from strontium-doped lanthanum cobaltite (LSC) infiltrated - Ce0.9Gd0.1O1.95 (CGO) ionic conducting backbone. Systematic tuning of the CGO and LSC firing temperatures and LSC loading resulted in a cathode with low polarization resistance, Rp = 0.044 cm² at 600°C. The most promising cathode was integrated onto an anode supported cell and it was found that the cell exhibits electrochemical stability with no measureable degradation during 1500 h operation at 700°C. LaCoO3 and Co3O4 infiltrated - CGO cathodes were also investigated and revealed that these nanoparticulate infiltrates have good oxygen reduction capabilities. The significance of the choice of ionic conducting backbone was also addressed by replacing the CGO with Bi2V0.9Cu0.1O5.35 (BICUVOX). Cathodes with a BICUVOX backbone exhibit performance degradation not observed in LSC infiltrated - CGO cathodes with increasing LSC firing temperature, highlighting the importance of materials compatibility over higher ionic conductivity. The potential of Ca3Co4O9+δ as an electrocatalyst for SOFCs has also been explored and encouraging results were found i.e., Rp = 0.64 cm² for a Ca3Co4O9+δ/CGO 50 vol % composite cathode at 600°C. A 1-dimensional model has been developed in order to understand and predict the performance of cathodes prepared by LSC infiltration. With the model, it was possible to extract an expression for the area specific resistance associated with oxygen surface exchange for the infiltrated LSC. The extracted values are significantly lower than literature values suggesting that the performance of LSC-infiltrated cathodes could not be explained by downscaled microstructure alone. A series of microstructural parameter variations are presented and discussed with the goal of guiding future studies on infiltrated cathodes.

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