ELECTROPHORETIC DEPOSITION OF CERAMIC COATINGS FOR SOLID OXIDE CELLS: CHALLENGES AND PERSPECTIVES

Federico Smeacetto, Department of Applied Science and Technology, Politecnico di Torino, Italy
federico.smeacetto@polito.it
Sebastian Molin, Gdansk University of Technology, Poland
Antonio G. Sabato, Catalonia Institute for Energy Research-IREC, Spain
Elisa Zanchi, Department of Applied Science and Technology, Politecnico di Torino, Italy
Grzegorz Cempura, AGH University of Science and Technology, Poland
Aldo R. Boccaccini, University of Erlangen-Nuremberg, Germany

Key Words: solid oxide cells, electrophoretic deposition, ceramics, area-specific resistance

Solid oxide cells (SOCs) are of great interest for efficient and clean power generation and highly efficient conversion of electricity to hydrogen, fuels and chemicals using high-temperature electrolysis.
Chromia-forming ferritic stainless steels (FSSs) are widely used as interconnect materials in solid oxide cell stacks because of CTE matching with ceramics parts, low cost and good formability. Ceramic-based coatings are currently used to protect metallic interconnects, limit the increase of the area-specific resistance (ASR) and suppress chromium poisoning of the oxygen electrode. In particular, manganese cobaltite MnCo spinel-based coatings have attracted great attention due to their high electrical conductivities at 750-850 °C and coefficient of thermal expansion matching with the FSSs. Understanding and controlling the evolution of the oxide scale-coating interface can provide the tools to further improve SOC stack durability and performance. There is also a growing interest in modifying the functional properties of MnCo spinel by transition metal doping (Fe, Cu); doped spinels generally are synthesized by ex-situ techniques, i.e. before the coating deposition, requiring time-consuming, energy-demanding and sequential processes.
Though the Electrophoretic deposition (EPD) has been used for the preparation of ceramic coatings for SOC interconnects in some studies, in our works, the Fe and Cu doping of the Mn-Co spinel is obtained “in-situ”, by EPD co-deposition of CuO and Fe_2O_3 and MnCo powders and subsequent two-step reactive sintering. The proposed approach represents a flexible and versatile method, allowing for modulating the dopant level, as well as saving time and costs of the synthesis process. Considering the powders particle size, their relative concentration and the zeta potential data, different EPD co-deposition mechanisms are proposed and discussed; The Fe_2O_3 particles are associated by electrostatic interaction with those of MnCo; the EPD co-deposition mechanism, to process a double side coated Crofer22APU together with EPD Fe-doped MnCo coating elements distribution is reported in figure 1. The role of EPD as a promising method for coating complex-shaped interconnects for solid oxide fuel cells and electrolyzers are also reviewed in a scale-up process, to coat real dimension plates in a stack. The innovative approach for the simultaneous electrophoretic deposition of three spinel precursors is designed, conceived and optimized, to outline time- and energy-saving spinel modification routes, thus providing insights for exploring the design of new spinel families (i. e. avoiding Co as a critical raw material). Since it is not possible to unquestionably outline the optimal coating solution (processing and sintering route, costs, environmental issues etc.), these research findings provide insights for future coating development, obtaining proper functional requirements to increase SOCs durability.

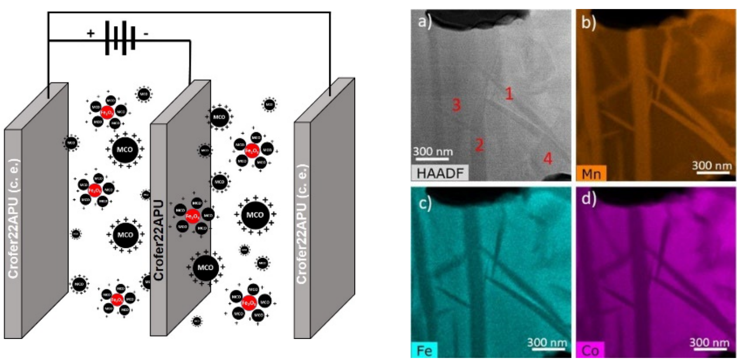

Figure 1 – EPD co-deposition mechanism for Fe-doped MnCo in a three electrodes set up and TEM image of EPD Fe-doped MnCo coating

References:
[1] E. Zanchi, F. Smeacetto et al, Journal of the European Ceramic Society 42 (2022) 3271–3281
[2] A. G. Sabato, F. Smeacetto et al, Journal of the European Ceramic Society 41 (2021) 4496–4504
[3] E. Zanchi, F. Smeacetto et al, Materials Letters 286 (2021) 129229