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Low temperature deposition of dense $MnCo_2O_4$ protective coatings for steel interconnects of Solid Oxide Cells

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Abstract

In this work manganese cobalt spinel ($MnCo_2O_4$) coatings were deposited on steel substrates by spray pyrolysis at 390 °C. This is at much lower temperatures than previously reported (typically in excess of 900 °C). It was possible to produce coatings with well controlled thickness (2-5-10 µm). The as-deposited coatings were evaluated for their microstructural changes and electrical conductivity up to 800 °C. Results confirm the formation of a single phase spinel with high density and electrical conductivity. Based on the obtained results, it might be concluded that spray pyrolysis is a very promising method to develop protective coatings for steel substrates at low temperatures overcoming limitations of many other methods.

Keywords: ceramics; deposition; electrical properties; corrosion;

Introduction

State of the art protective ceramic coatings for the steel interconnects of Solid Oxide Cells are based on the $Mn_{3-x}Co_xO_4$ spinel [1–3]. This material offers high electrical conductivity, good thermal expansion coefficient match to typical stack components and good protection against Cr evaporation and poisoning of the oxygen electrodes. Though the material is used for many years, development of cost efficient and simple fabrication routes is still of scientific interest. For protection against chromium evaporation, the coatings should form a dense structure, thus many research works focused on sintering and densification of the coatings. Typically, the coating is at first deposited as a powder and then it is subsequently heat treated. Two-step sintering seems to be the most common method [4]. Firstly the spinel is reduced to metallic Co and MnO, and then it is reoxidized in air. This procedure offers high density, but requires long processing and the reduction step, complicating the manufacture of coated interconnects. Other methods for low temperature sintering of $MnCo_2O_4$ and other similar spinels are researched [5,6].

Spray pyrolysis is a solution based deposition method, that offers the possibility to produce ceramic layers at relatively low temperatures [7–10]. In the spray pyrolysis process, liquid precursor containing metal cations is delivered to the spraying nozzle, where it is air atomized to form fine droplets. Subsequently these are transported with the gas stream towards the heated sample surface. Droplets spread on the heated surface, solvent evaporates and the nitrates decompose to form amorphous or crystalline deposits. After buildup of many droplets a continuous layer/coating is formed. There are several parameters that need to be controlled in order to obtain high quality layers: gas pressure and flow rate, liquid flow rate, distance between the nozzle and the hot plate, temperature of the sample surface.