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Electrodeposition of yttria/cobalt oxide and yttria/gold coatings onto ferritic stainless steel for SOFC interconnects

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ABSTRACT

Durability seems to be the single most critical issue for the widespread application of SOFCs. Among critical issues, the stability of interconnects – operating at high temperatures in aggressive gas environments – calls for the selection of cheap materials exhibiting high corrosion performance, accompanied by low surface contact resistance. Use of coated AISI 430 stainless steel is currently the state-of-the-art choice. In this paper we propose Y_2O_3, Y_2O_3/Co_3O_4 and Y_2O_3/Au composite films as innovative coatings for AISI 430 plates. These coatings were electrodeposited from chloride salts dissolved in hydroalcoholic solutions containing chitosan as binder. The evolution of the crystalline structure of the electrodeposits with heat-treatment conditions has been studied by XRD, their chemical composition has been evaluated by EDX analysis, their morphology has been observed by SEM and the adhesion has been measured by scratch testing. Coated samples were oxidised in air at 800 °C for times up to 500 h and the area-specific resistance (ASR) as a function of exposure time has been measured. All the coated samples developed ASR values below 100 mΩ cm^2, the target value for SOFC applications. The ASR was found to increase in the order: Y_2O_3/Au, Y_2O_3, and Y_2O_3/Co_3O_4.

1. Introduction

In intermediate-temperature SOFCs – operating in the typical range 600–800 °C – the material of choice for interconnects are ferritic stainless steel grades, AISI 430 in particular. The chief reasons for this material selection are adequate high-temperature mechanical and chemical properties, coefficient of thermal expansion matching the other fuel cell stack components and cost-effectiveness [1]. Nevertheless, the use of this material is not devoid of drawbacks. Specifically, (i) the high Cr content tends to lead to the formation of volatile Cr compounds that end up poisoning the catalysts and (ii) oxides forming on the bare ferritic stainless steel have a relatively low electrical conductivity, resulting in a build-up of series ohmic resistance at each contact. Interconnect durability issues are currently believed to be the single most critical source of cell degradation, limiting the lifetime of planar SOFC systems implementing metallic interconnects [2,3].

An approach towards minimising such disadvantages is resorting to the use of coatings that exhibit the dual action of protecting against high-temperature corrosion in O_2 and preserving a high electrical conductivity of the surface. $La_{1-x}Sr_xMnO_3$ films were deposited by slurry-dipping [4] and plasma-sputtering [5]. Recently, mixed Mn–Co oxide coatings have been fabricated by anodic electrodeposition from Mn^{2+} and Co^{2+} sulphate baths [6]. Good performances were obtained by coatings of yttrium oxide [7,8], mixed yttrium/cobalt oxide [8,9] or mixed yttrium/cerium oxide [9] prepared by sol–gel techniques. Wei et al. [10] electrodeposited composite yttria–Ag coatings from Ag^+ and Y^{3+} nitrate solutions by a multiple-step approach as well as praseodymia coatings from a chloride bath containing PDDA as binder. After thermal treatment at 750 °C the yttrium and praseodymium oxides react with chromium oxide giving rise to the formation of uniform, dense and protective $YCrO_3$ and $PrCrO_3$ perovskite layers, able to prevent the progress of oxidation. Furthermore, contact-resistance measurements have shown that these systems exhibit a low electrical resistance, with limited increase with oxidation time.

Moreover, the electrosynthesis of oxide-based coatings has proved attractive in other fields where the prevention of high-temperature oxidation of stainless steel is required. Electrodeposition of adherent, corrosion resistant Al_2O_3 and Al_2O_3–YSZ coatings has been reported in [11–13] and [13], respectively.

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