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STRUCTURE OF MATTER AND QUANTUM CHEMISTRY

Electrochemical Synthesis and Properties of Ceria Films Grown on Stainless Steel[1]

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Abstract—Electrochemical synthesis of ceria films was performed on a stainless steel substrate in view of Solid Oxide Fuel Cells (SOFC) applications. Films were obtained from aqueous nitrate solutions via cathodic deposition method at room temperature. A constant potential value of –0.8 V/(SCE) was applied to reduce the molecular oxygen as hydroxide precursor, leading to a formation of adherent, homogeneous and covering films in 20 min deposition time. Structure, morphology and composition of as-grown coatings were studied by X-ray diffraction, Raman and energy-dispersive X-ray spectroscopy, as well as scanning electron microscopy. Cubic fluorite-type nanostructured ceria of leaf-like particles was synthesized. Thermal annealing (600°C, 1 h) was found to enhance ceria crystallinity.

Keywords: electrochemistry, synthesis, ceria films, crystallinity.

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INTRODUCTION

Ceria (CeO_2) and ceria-based oxides exhibit high oxygen ion conductivity, oxygen storage capacity, high mechanical strength and strong UV absorption properties. These unique properties have resulted in a wide range of applications of ceria-based materials such as gas sensors, supports or promoters for three-way catalysts (TWC), ultraviolet (UV)-shielding materials, polishing agents for chemical mechanical planarization process [1–5]. Ceria and other rare earth compounds were also proved efficient against corrosion of different metallic materials and considered as environment friendly alternatives to the highly toxic chromate coatings [6–8].

However, one of the most important applications of ceria-based films is in Solid Oxide Fuel Cells (SOFCs). They can be used as promising oxygen conducting electrolytes when doped, interfacial catalytic layers between electrodes and electrolytes, chemical diffusion barriers or protective coatings for interconnect materials [9–14]. Indeed, ceria layers could prevent or reduce the corrosion of ferritic stainless steel bipolar plates.

In the past decade, controlled synthesis of ceria-based nanomaterials with required characteristics in term of size, uniformity, morphology, specific surface area and crystallinity has become one of the essential topics in material science, since their outstanding performances can be amplified by tuning material properties [15, 16]. Numerous physical and chemical methods such as sol–gel, hydrothermal synthesis, spray pyrolysis, homogeneous precipitation, combustion synthesis, sonochemical and microwave assisted techniques [17–22], to name just a few, have been reported for the synthesis of ceria-based materials with promising properties. However, most of these techniques are complex, energy consuming and expensive.

The electrochemical technique, often called Electrolytic Deposition (ELD) or Electrochemical Generation by Base Method (EGBM), represents a powerful and cost-effective route, suitable for producing high-quality ceria thin films on any shaped conductive substrate. It provides an easy way to vary the process parameters (electrolyte acidity level, reactant concentrations, temperature, deposition time) and, therefore, to control or tailor the deposit characteristics (thickness, morphology). The method is based on the reduction of oxygen precursor to generate the hydroxide ions in the vicinity of the working electrode. Consequently, the pH in the immediate vicinity of the electrode is higher. If the Ce^{3+} ions are present in the electrolytic solution, they react with the OH^- ions and the cerium-based components are directly formed by precipitation on the conductive substrate, which acts as a working electrode [6, 23]. Then, oxidation of

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