Synthesis and characterization of NiO-8YSZ powders by coprecipitation route

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Abstract. Nickel oxide – 8 mol% yttria stabilized zirconia (NiO-8YSZ) powders containing 25 to 75 wt% of NiO were prepared by coprecipitation. The entire process includes the reaction of metals aqueous chloride solutions (heated at 95 °C) with ammonium hydroxide, washing steps of the resulting gel, butanol azeotropic distillation treatment to prevent the formation of hard agglomerates, drying, calcination and ball milling. The yield of precipitation of metals was determined by inductively coupled plasma atomic emission spectroscopy analysis (ICP-AES). Powders were characterized by X-ray and laser diffraction, infrared analysis, gas adsorption (BET) and scanning electron microscopy. It was observed that zirconium and yttrium hydroxides are easily precipitated in alkaline medium, while nickel precipitation yield is in the range of 80 to 95% due to the formation of soluble complexes. NiO appears as a second phase in synthesized powders and contributes to decreasing of specific surface area and agglomerate mean size.

Introduction

The incorporation of metallic nickel or nickel oxide particles in yttria stabilized zirconia (YSZ) ceramics has made possible the development of mixed ionic-electronic composites applied in solid state ionic devices such as solid oxide fuel cell electrodes and flow sensors [1-5]. Ni-YSZ can also be used as thermal barrier coating (TBC) to reduce the mismatch strains between the coatings and the metallic substrate [6]. The advantages in choosing NiO/Ni, as a second phase, include its low cost, the stability over a wide range of temperatures, the limited solubility in solid solution (< 2mol% at 1600 °C) and the absence of reaction products or intermediates phases [1-7].

In recent years, increasing efforts directed towards the development of NiO-YSZ synthesis and ceramic processing is due to the great interest in fuel cell technology for high efficiency, environmental friendly power generation. State-of-the–art anode for Solid Oxide Fuel Cells (SOFC) is a nickel-8 mol% yttria stabilized zirconia (Ni-8YSZ) composite, obtained by reduction in situ of NiO-8YSZ cermet. The nickel particles, forming a percolative network, have a high catalytic activity for hydrogen oxidation and are responsible for transporting electrons from the electrode reaction site to the external circuit. YSZ matrix supports nickel particles, inhibits coarsening by sintering during SOFC operation and gives a thermal expansion coefficient close to the other cell components [2-4].

Mechanical mixing of powders is the technique usually employed for the manufacture of NiO-YSZ anode [4]. However, a uniform distribution of nickel particles in the ceramic matrix is difficult to be assured as a consequence of differences in powder densities and size distributions. For a better control of anode microstructure, several techniques such as mechanical alloying [8], coprecipitation [9-11], polymeric precursors [12] and combustion [13, 14] have been proposed for synthesis of NiO-YSZ powders.