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Sintering Analysis of Chemical Synthesized Nanocrystalline 8YSZ Powders

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Abstract – The understanding of the mechanisms associated with densification and sintering of nanostructured yttria stabilized zirconia (YSZ) enables the improvement of its microstructure. This motivated the present work that has the objective to study the sintering and densification processes of polycrystalline nanostructured 8mol% Y_2O_3 stabilized ZrO_2. The isothermal and non-isothermal sintering behaviors of nanocrystalline YSZ powders obtained by two different chemical synthesis techniques (glycine-nitrate combustion process, GNP, and Pechini method) were studied based on the development of master sintering curves from non-isothermal sintering of the YSZ nanopowder compacts using a sintering dilatometer method.

The efficiency of energy conversion of a SOFC (solid oxide fuel cell) and its performance durability mainly depend on the oxide ion conducting solid electrolyte activity [1]. In this context, the 8 mol% yttria-stabilized zirconia (8YSZ) is the most common material used as electrolyte in SOFC due to its pure oxygen-ion conductivity, good chemical compatibility, stability in dual environment (oxidizing and reducing) and thermal stability [1]. An important requirement for a SOFC electrolyte material is its high density (low porosity). The sample's density influences its electrical and mechanical properties and, especially, increasing its ionic conductivity [2]. However, the sintering mechanism of 8YSZ powders is not yet established [3]. Thus, the aim of this work is to characterize and evaluate the microstructural densification of 8YSZ materials prepared from chemical synthesized powders, based on results from dilatometry experiments and contribute to the understanding of the processes of densification and sintering of this material.

The sintering of the chemically synthesized powders was performed in a thermo-dilatometer (Netzsch STA 402/409E) up to 1550°C in air under non-isothermal conditions with 3^0C/min heating rate, and cooled to room temperature. After measurement of the anisotropic coefficient (measurement of the shrinkage in 2 perpendicular directions) the linear shrinkage as a function of temperature, was used to trace the instantaneous densification normalized rate ($(1/\rho)d\rho/dt$) – where ρ is the instantaneous density and t is the time – as a function of the degree of advancement of the densification (relative density) with respect to the theoretical density of the 8YSZ. Figure 1 shows the thermal etched surface images of the sintered pellets studied.

Figure 2 shows the curves of densification rate as a function of the densification degree for the 8YSZ systems studied. It is clear that in the beginning up to about 90% of the theoretical density, the evolved mechanisms are essentially the same, although the densification kinetics of the GNP-synthesized powders has been slightly faster than the powder synthesized by the Pechini method. In fact, the initial slopes are almost identical for the two powder systems studied. This situation reverses after about 93% of densification degree is attained, already in the decreasing part of the curves, then when it seems that the densification rate of the GNP-synthesized system becomes slow. The final relative densities achieved (98.4 ± 0.4) and (96.9 ± 0.8) percentages of the theoretical density, respectively for the Pechini-synthesized and GNP-synthesized samples, are also consistent with those determined by the Archimedes method.

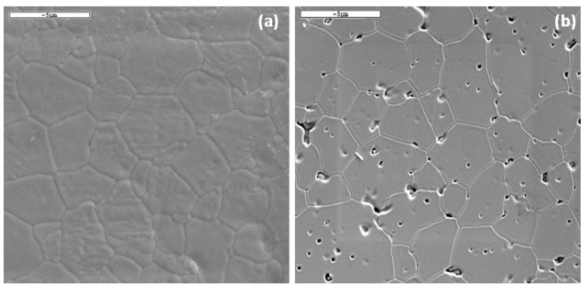

Figure 1: SEM micrographs of sintered 8YSZ specimens, after thermal etching, which powders were produced by: (a) Pechini method; (b) GNP.

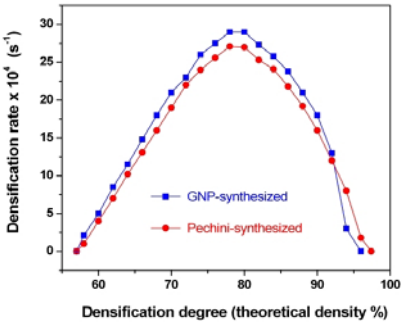

Figure 2: Densification rate as a function of the densification degree (relative density) for the 8YSZ samples studied.

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