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Structural and electrical properties of $La_{0.7}Sr_{0.3}Co_{0.5}Fe_{0.5}O_3$ powders synthesized by solid state reaction

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Abstract

This work investigates the effect of synthesis parameters (calcination temperature, milling conditions and sintering temperature) on the structural, morphological and electrical properties of $La_{0.7}Sr_{0.3}Co_{0.5}Fe_{0.5}O_3$ (LSCF) powders prepared by the solid state reaction. The thermogravimetric profile showed that the minimum temperature needed for the carbonate decomposition and formation of perovskite phase is 800 °C. SEM analysis revealed the loose and porous structure of the powder materials. The XRD patterns demonstrate that milling parameters such as grinding balls:sample ratio, rotational speed, and milling time influence the structural properties. The results revealed that powders synthesized with grinding balls:sample ratio of 8:1, 500 rpm and 4 h of milling present pure LSCF phase. Porosity of the pellets decreased with increasing sintering temperature from 950 to 1100 °C. Electrical conductivity was measured at 400–1000 °C and correlated with sintering temperature.

Keywords: Sintering; Solid state; Mechanochemical synthesis; LSCF

1. Introduction

Perovskite-type oxides $LaMO_3$ (M = Mn, Co, Fe and Ni) have been widely investigated as potential oxidative catalysts and electrodes for solid oxide fuel cells (SOFC), because they are able to reduce molecular oxygen and transport oxide ions [1]. Particularly, $La_{1-x}Sr_xCo_{1-y}Fe_yO_3$ (LSCF) compositions have attracted substantial interest because of their superior mixed electronic–ionic conduction, which make them promising cathode materials for intermediate temperature solid oxide fuel cells (IT-SOFC) [2,3].

The structural and electrical properties of LSCF oxides depend greatly on their composition and synthesis method. An appropriate synthesis condition of powder is very important because this affects several properties such as phase purity and particle size. A coarse structure improves gas permeability and ionic and electronic conductivities, while a fine structure leads to a high specific surface area and therefore to a large number of reaction sites [4].

Several synthesis methods have been used for preparation of perovskite powders, such as solid state reaction, combustion method and some chemical solution methods, for example, sol–gel, coprecipitation, and citrate process [5–8]. The solid state reaction is a conventional method of ceramic processing; it is simple and low-cost to operate and uses cheap and easily available oxides as starting materials. However, this method usually involves high temperatures and leads to large particle sizes and limited degree of chemical homogeneity [9,10]. Thus, more detailed studies regarding the influence of synthesis parameters are needed to reduce the processing temperatures and improve structural properties.

Zhang et al. [9,11] synthesized $LaMnO_3$ using a high-energy ball mill at room temperature, producing fine powders with large surface area. It is known that the chemical reactivity of starting materials can be improved significantly after mechanochemical activation and, subsequently, the calcination temperature is reduced [12]. The mechanochemical method is characterized by the repeated welding, deformation and fracture of the constituent powder materials. With continued mechanical deformation there is an increase in surface energy, which may affect the structural and physico-chemical properties of the material [13]. Using the

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