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Effects of Co and Fe addition on the properties of lanthanum strontium manganite

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Abstract

The effects of Co and Fe dopants with the amount of 20 and 40 mol% on the properties of $La_{0.84}Sr_{0.16}MnO_3$ were investigated. All compositions were prepared by conventional mixed oxide process and sintered at 1450 °C. The structure of undoped and Co-doped compositions was found to be monoclinic. In addition, the second phase was observed in these sintered compositions. The conductivity of doped materials decreased as compared to that of $La_{0.84}Sr_{0.16}MnO_3$. The SEM microstructure showed the decrease of grain size as Co content increased. The thermal expansion coefficient (TEC) tended to increase as Co content increased. In contrast, the monoclinic and orthorhombic structures were found in 20 and 40 mol% Fe-doped $La_{0.84}Sr_{0.16}MnO_3$. The amount of second phase in sintered composition depends on the amount of Fe content. The conductivity at 1000 °C decreased, but the grain size increased as Fe content increased. The thermal expansion coefficient slightly changed with Fe addition.

Keywords: Solid oxide fuel cell; Lanthanum strontium manganite; Electrical conductivity

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Lanthanum strontium manganite ($La_{1-x}Sr_xMnO_3$, LSM) is extensively used as cathode material for a solid oxide fuel cell (SOFC) because it offers high electronic conductivity, high catalytic activity for oxygen reduction and chemical and thermal compatibility with yttria-stabilized zirconia (YSZ) electrolyte at the operating temperature [1]. LSM is a perovskite oxide ABO_3 where La^{3+} ions in the A-sites are partially substituted by Sr^{2+} ions. Its structure has been reported to be rhombohedral [2–4] or monoclinic [5], depending on the amount of Mn^{4+}, which can be varied by sintering atmosphere, temperature and Sr^{2+} content. $LaMnO_3$ is a p-type semiconductor due to small polaron hopping of holes [1]. Doping of Sr into $LaMnO_3$ increases the electrical conductivity considerably because a number of holes increase [1]. Nevertheless, an increase of Sr also increases the thermal expansion coefficient (TEC) [3,4] and affects the chemical reaction with YSZ at high operating temperature [6–8], resulting in the degradation of cell performance.

To promote SOFC towards commercialization, there have been many attempts to develop the suitable materials for lower operating temperature below 900 °C without impeding its performance. The possible perovskite materials such as $LaCoO_3$ and $LaFeO_3$ have been studied. $LaCoO_3$ has much higher electrical conductivity than $LaMnO_3$, however, its thermal expansion coefficient is much greater than that of YSZ electrolyte [1]. In addition, it easily reacts with YSZ and forms the insulating layer at high temperature [1]. $LaFeO_3$ has higher catalytic activity for oxygen reduction at the lower temperature [9,10], possibly offering the good electrical properties. The objective of this work was to study the effect of Co or Fe addition into Lanthanum strontium manganite system. Although the other cations such as Mg, Ti and Nb [11] have been studied, Co and Fe are possible dopants to improve the properties of this composition. In this paper, $La_{0.84}Sr_{0.16}MnO_3$ was selected as the base material. The crystal structure, phase, thermal expansion coefficient and

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