Asian Journal of Chemistry; Vol. 25, No. 10 (2013), 5751-5752

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2013.OH80

Preparation and Electrochemical Performances of $Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (x = 0.5, 0.6, 0.7) as Potential Cathode Material for Solid Oxide Fuel Cells†

WEITAO BAO* and HONG SUN

Department of Chemistry and Materials Engineering, Anhui University, Hefei 230601, P.R. China

*Corresponding author: Fax: +86 551 2158436; E-mail: bwt@hfuu.edu.cn

AJC-13324

A perovskite oxide $Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (BSCF, x = 0.5, 0.6, 0.7) is investigated as a cathode material for solid oxide fuel cells. The BSCF is prepared using solid state reaction method. The XRD shows the perovskite phase is formed at x = 0.5 and impurity phases are detected with x increasing. The area specific resistance value for the BSCF cathode is as low as 0.07 Ω cm^2 at 750 ºC as x = 0.5. The electrolyte-supported fuel cell generates good performance with the peak power densities of 0.078, 0.057, 0.032 Wcm^{-2} at 750 ºC as x = 0.5, 0.6, 0.7, respectively.

Key Words: Solid oxide fuel cells, Perovskite structure, Cathode.

INTRODUCTION

Solid oxide fuel cell (SOFC) system is considered to have superior potential for commercialization due to its high energy conversion efficiency, self-reforming ability, compatibility with common hydrocarbon fuels, use of solid state materials and no need of noble metals as catalysts[1]. In recent years, enormous research efforts have been invested on the development of intermediate temperature solid oxide fuel cells (IT-SOFCs) capable of operating at temperatures between 500 and 700 ºC[2]. The performance of LSM cathode declines drastically as the operating temperature drops, due to its low oxygen ion conductivity and high activation energy for oxygen dissociation[3,4]. Accordingly, new materials have been developed to improve the performance of the cathodes. Here, preparation and electrochemical performances of a potential cathode material $Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (x = 0.5, 0.6, 0.7) were studied.

EXPERIMENTAL

$Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (BSCF) were synthesized by a conventional solid-state reaction. Briefly, Bi_2O_3, Co_2O_3, $SrCO_3$ and Fe_2O_3 were weighed in the stoichiometric proportions of BSCF. The mixture was ground thoroughly and pressed, then fired repeatedly at 850 ºC for 5 h in air. $Ce_{1.8}Sm_{0.2}O_2$ (SDC) and NiO powders were synthesized using the glycine-nitrate combustion method. Symmetrical electrochemical cells with the configuration of electrode/SDC/electrode were applied for the impedance studies. The SDC powder was dry-pressed into pellets about 13 mm in diameter and 1mm thick under 200 MPa and sintered at 1350 ºC for 5 h in air to obtain a dense electrolyte substrate. Suitable slurries were made up by mixing BSCF powders with an organic solvent (10 % ethyl cellulose + 90 % terpineol) and screen printed onto both sides of SDC electrolyte pellet (the thickness of electrode is about 40 μm), followed by calcining at 800 ºC for 1 h. Then silver paste was applied to electrode surfaces to serve as current collectors. The crystal structure was characterized by an X-ray diffractometer (XRD).

RESULTS AND DISCUSSION

Fig. 1 shows XRD patterns of BSCF powders. When x = 0.5, the crystal phase is pure perovskite structure. With an increase of x value, the second phases, such as Bi_2O_3 and SrO, are detected (Fig. 2b and c). Due to Bi_2O_3 having low melting point, the formation of Bi_2O_3 liquid aggregates at fired temperatures will inhibit the solid state reaction to form the as-required phase and make Bi_2O_3 residual.

Fig. 2 shows the impedance spectra of symmetrical electrochemical cells measured at different temperatures in air. The arc observed can be associated with the interfacial impedance between the BSCF cathode and the SDC electrolyte. As expected, an increase of the measurement temperature resulted in a significant reduction of the area specific resistance (ASR). The area specific resistances of BSCF cathode on SDC

†Presented to the 6th China-Korea International Conference on Multi-functional Materials and Application, 22-24 November 2012, Daejeon, Korea

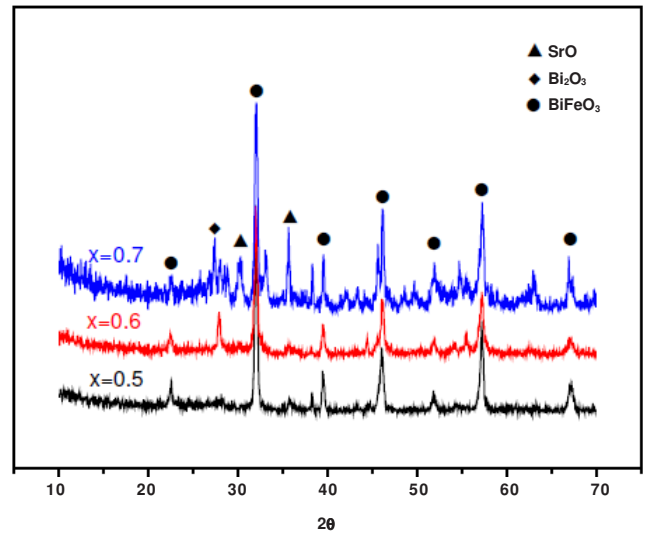

Fig. 1. XRD patterns of $Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (x = 0.5, 0.6, 0.7) powders

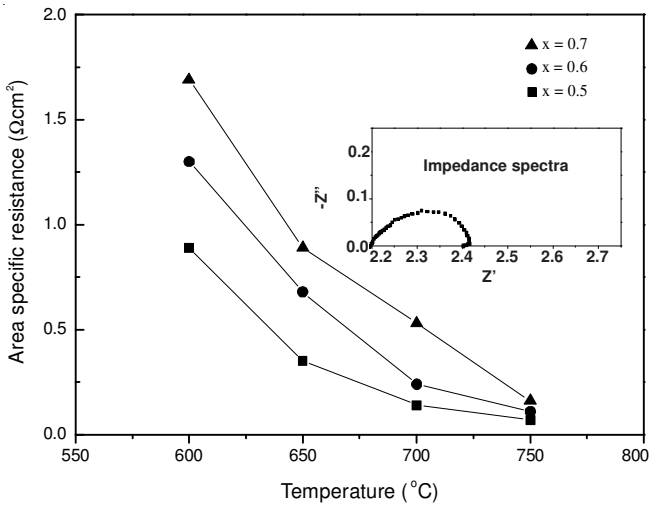

Fig. 2. Area specific resistance of BSCF/SDC/Ni-SDC cells as a function of temperature

electrolyte are 0.07, 0.11 and 0.16 Ω cm^2 at 750 ºC as x = 0.5, 0.6, 0.7, respectively. These values (x = 0.5, 0.6) are much lower than that expected for the area specific resistance of the $La_{0.7}Sr_{0.3}MnO_3$ cathode, which is lower than 0.15 Ω cm^2 at operating temperature. The low area specific resistance values indicated that BSCF cathode has high-electrocatalytic activity for oxygen-reduction reactions at intermediate temperatures. This excellent cathode performance of BSCF maybe related to fast oxygen diffusion in the bulk and high surface kinetics on the surface of electrode.

Fig. 3 shows the power densities for Ni-SDC/GDC/SDC/BSCF cell using H_2 as the fuel and static air as the oxidant in 750 ºC. Peak power densities are 0.078, 0.057, 0.032 Ω cm^{-2} at 750 ºC as x = 0.5, 0.6, 0.7, respectively. The power densities decrease with x increasing, this is because of the formation of the impurity phases in perovskite oxie BSCF as x is more than 0.5.

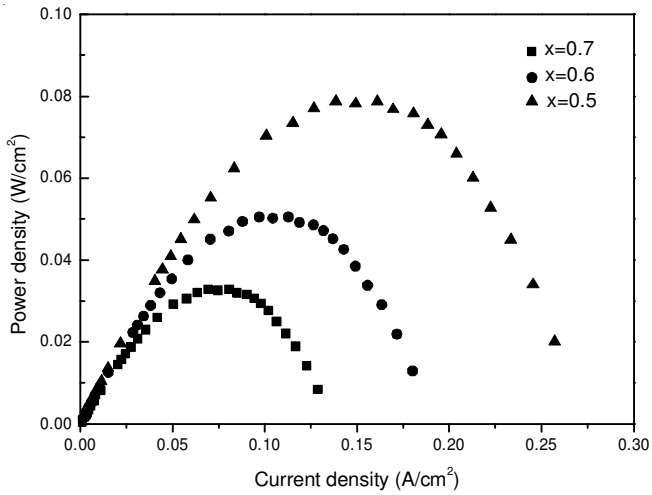

Fig. 3. Power density as functions of current density at 750 ºC.

Conclusion

$Bi_xSr_{1-x}Co_{0.2}Fe_{0.8}O_3$ (BSCF) cathode material was synthesized using solid state reaction method. The BSCF cathode exhibited excellent behaviour with area specific resistance value of 0.07 Ω cm^2 at 750 ºC as x = 0.5. The peak power densities of a single-cell were 0.078, 0.057, 0.032 Wcm^{-2} using H_2 as the fuel and static air as the oxidant at 750 ºC as x = 0.5, 0.6, 0.7, respectively. All results considered, BSCF cathode is a promising material for IT-SOFC based on SDC electrolyte.

ACKNOWLEDGEMENTS

This work was supported by the natural science foundation of education department of Anhui province under contract No. KJ2012ZD15.

REFERENCES

1. A.B. Stambouli and E. Traversa, *Renew. Sustain. Energy Rev.*, **6**, 433 (2002).
2. E.I. Tiffée, A. Weber and D. Herbstritt, *J. Eur. Ceram. Soc.*, **21**, 1805 (2001).
3. Z.W. Wang, M.J. Cheng, Y.L. Dong, M. Zhang and H.M. Zhang, *Solid State Ionics*, **176**, 2555 (2005).
4. B.C.H. Steele, *Solid State Ionics*, **86-88**, 1223 (1996).