International Journal for Modern Trends in Science and Technology
Volume 9, Issue 11, pages 35-37.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol9issue11.html
DOI: https://doi.org/10.46501/IJMTST0911007

Synthesis and characterization (phase, microstructure and porosity) of Li doped BCZT ceramics for Fuel Cell and clean energy technology

Camilo I. Jimenez Bravoa[1,*], V. Raghavendra[2,*], Koduri Ramam[1,*], F. Sanhueza[1]

[1]Laboratorio de Tecnologías Electroquímicas y Energías Verdes, Departamento de Ingeniería de Materiales, Facultad de Ingeniería, Universidad de Concepción, Concepción, Chile
[2] Department of Physics, Sri Venkateswara College, University of Delhi, New Delhi, India
Corresponding Authors: camiljimenez@udec.cl , raghavendra.vemuri@svc.ac.in

To Cite this Article
Camilo I. Jimenez Bravoa, V. Raghavendra, Koduri Ramam and F. Sanhueza. Synthesis and characterization (phase, microstructure and porosity) of Li doped BCZT ceramics for Fuel Cell and clean energy technology, International Journal for Modern Trends in Science and Technology, 2023, 9(11), pages. 35-37.https://doi.org/10.46501/IJMTST0911007

Article Info
Received: 19 October 2023; Accepted: 12 November 2023; Published: 15 November 2023.

ABSTRACT

In this work, we present phase and structural investigation of pure and Li (=0.08) modified perovskite structured 0.480. [Ba (Zr0.25Ti075)O3]-52(Ba0.75Ca0.25)TiO3 ceramics for versatile applications.Pure and Li modified BZT-BCT ceramic materials were synthesized by hydrothermal method. Powder X-ray diffraction studies showed single and pure rhombohedral phase formation in both pure and Li modified BZT-BCT ceramic systems. Scanning electron microscopy studies revealed that Li (=0.08) modified BZT-BCT has shown porous structure formation which is favorable microstructure features and is suitable for Fuel Cell technology and clean energy technologies as potential electrode materials.

KEYWORDS: Perovskite, Li, BZT-BCT, hydrothermal process, porous microstructure, Fuel Cell and clean energy application

1. INTRODUCTION

Ferroelectric materials with a perovskite structure have been extensively studied due to their wide applications in the fabrication of multilayer ceramic capacitors, actuators and electromechanical transducers[1] Lead-based perovskite solid solution of Pb (Zr,Ti)O_3 (PZT) have been widely used for piezoelectric devices due to their large piezoelectricconstant [2-4].Lead-free materials with perovskite structure such as $BaTiO_3$ (BT)[5,6], Ba1-xCaxTi1-yZryO_3 (BCZTO) [7-9] (Bi, Na) TiO_3 (BNT)[10], and (Na, K) NbO_3 (NKN) [11]. Recently, it was reported that the addition of $Li2CO_3$ as a sintering additive could improve both the sinterability and the piezoelectric properties, where Li+ was doped into the lattice of $BaTiO_3$ during the sintering. Li_2CO_3 is a promising additive to reduce the sintering temperature for ($Ba_{0.85}Ca_{0.15}$) ($Zr_{0.1}Ti_{0.9}$)O_3 (BCZT) ceramics[12-14]. Pure and Li modified BZT-BCT ceramic

materials were synthesized by hydrothermal method. In this work, we present phase and structural investigation of pure and Li (=0.08) modified perovskite structured 0.480. [$Ba(Zr_{0.25}Ti_{075})O_3$]-52($Ba_{0.75}Ca_{0.25}$)TiO_3 ceramics for versatile applications.

2. EXPERIMENTAL

The stoichiometric pure and Li (=0.08) modified BZT-BCT ceramic powders, respectively were prepared byhydrothermalmethod using high pure reactive of $Ba(OH)_4$, $Ca(NO_3)_2.4H_2O$, $ZrCl_2O.8H_2O$, $TiO_2$and Li_2CO_3. Primarily, stoichiometric ratios of reactivewere dissolved in de-ionized water under continuous magnetic stirring for 20 hours, and then, 10 M NaOH solution was mixed to the initial mixture followed by magnetic stirring the total solution for 20 hours at 25 °C. After completing the magnetic stirring, the solution was transferred to the hydrothermal reactor consisting of Teflon-lined stainless-steel autoclave, and started the hydrothermal treatment at 240° C for 24 hours, followed by cooling naturally to the room temperature. The hydrothermal reacted product was purified by washing with de-ionized water toremove sodium ions and any remanent ions, and then dried the product in an oven at 80° C to obtain pure and Li(=0.08) modified PZT-PCT ceramic powders, respectively. These powders were then mixed with 5wt% poly vinyl alcohol (PVA) binder and mixed well and compacted to circular disks (i.e., pellets) followed by sintering these green pellets at 1225°C for 3 hours and cooled to room temperature naturally, and thus obtained sintered ceramics for further phase genesis and microstructure characterizations.

The sintered ceramics were analyzed by the powder X-ray diffraction (Bruker Endeavor X-ray diffractometer model D4/MAX-Bat at a scanning rate of 0.02 °/min over a range of Bragg angles 2θ between 20 and 70°) for the phase formation in the respective ceramic compositions. The apparent densities of the respective sintered samples were measured through the Archimedes method. As sintered ceramic surfaces were analyzedwith scanning electron microscopy (SEM; JEOL model JSM 840A) for the microstructure analysis.

3.RESULTS AND DISCUSSION

3.1 XRD

Figure 1 shows X-ray diffraction patters of pure and Li modified BZT-BCT ceramics. XRD results confirm the rhombohedral phase[15]in the pure and Li modified BZT-BCT perovskite ceramics. No secondary or impurity phases were observed. All the peaks showed rhombohedral structure with homogenous phase genesis and formation. As Li was incorporated into BZT-BCT lattice, the rhombohedral phase strengthened.

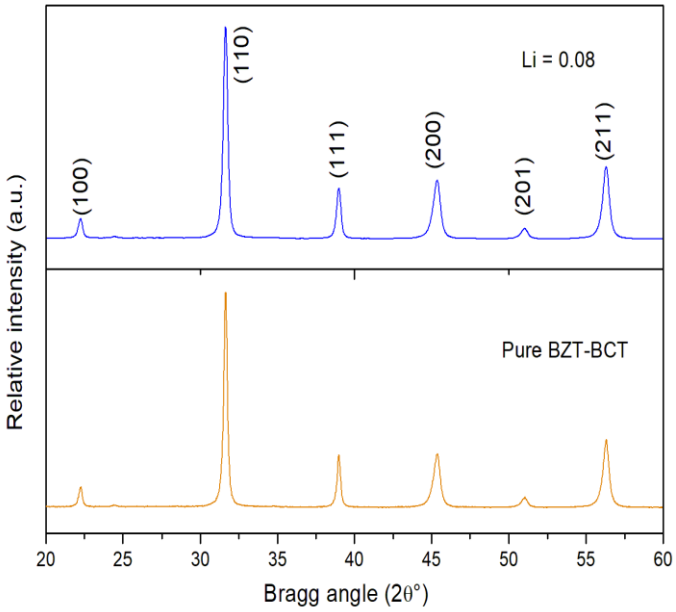

Figure 1: Powder X-ray diffraction patterns of pure and Li (=0.08) modified BZT-BCNT ceramic systems

3.2 Microstructure

Figure 2 shows SEM images of pure and Li modified BZT-BCT ceramics. Microstructure studies reveal that in the pure composition grains were intact, dense and homogeneous distribution can be observed. As Lithium was introduced in the BZT-BCT system, the grains got separated forming porous structures and well-dispersed suitable for electrode materials in the Fuel Cell applications.

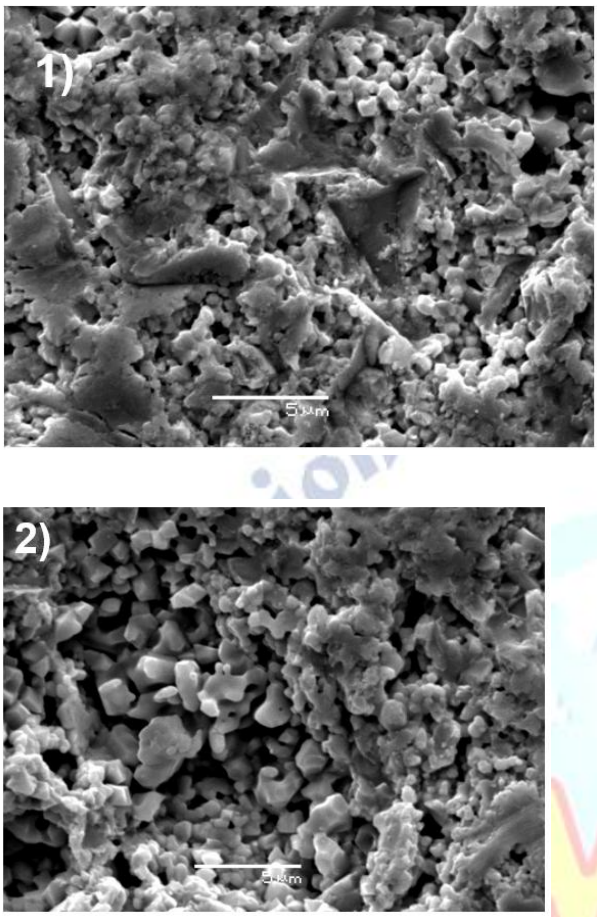

Figure 2: SEM micrographs of pure and Li(=0.08) modified BZT-BCT ceramic system

4 CONCLUSIONS

Pure and Li modified BZT-BCT ceramic materials were synthesized by hydrothermal method. X-ray diffraction patters of pure and Li modified BZT-BCT ceramics. XRD results confirm the rhombohedral phase in the pure and Li modified BZT-BCT perovskite ceramics. SEM images of pure and Li modified BZT-BCT ceramics. Microstructure studies reveal that in the pure composition grains were intact, dense and homogeneous distribution can be observed.

Acknowledgements

We acknowledge the Fondecyt Project N° 1110583, ANID, Chile, Universidad de Concepcion for their financial support and C. Ranganathan for his technical assistance in carrying out this research work.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] J.F. Tressler, S. Alkroy, R.E. Newnham, Piezoelectric sensors and sensor materials, J. Electroceram. 2 (1998) 257–272.

[2] Koduri, R., & Lopez, M. (2008). Influence of Mn on dielectric and piezoelectric properties of A-site and B-site modified PLZT nano-ceramics for sensor and actuator applications. Journal of Materials Science: Materials in Electronics, 19, 669-675.

[3] Ramam, K., & Lopez, M. (2008). Microstructure, dielectric and electromechanical properties of PLSZFT nanoceramics for piezoelectric applications. Journal of Materials Science: Materials in Electronics, 19, 1140-1145.

[4] Ramam, K., & Lopez, M. (2006). Ferroelectric and piezoelectric properties of Ba modified lead zirconium titanate ceramics. Journal of Physics D: Applied Physics, 39(20), 4466.

[5] H. Takahashi, Y. Numamoto, J. Tani, S. Tsurekawa, Piezoelectric properties of BaTiO3 ceramics with high performance fabricated by microwave sintering, Jpn. J. Appl. Phys. 45 (2006) 7405.

[6] K. Tomoaki, Y. Kang, A. Masatoshi, Barium titanate piezoelectric ceramics manufactured by two-step sintering, Jpn. J. Appl. Phys. 46 (2007) 7035

[7] X.-G. Tang, Effect of grain size on the electrical properties of (Ba,Ca)(Zr, Ti)O3 relaxor ferroelectric ceramics, J. Appl. Phys. 97 (2005) 034109.

[8] S.K. Rout, E. Sinha, S. Panigrahi, J. Bera, T.P. Sinha, Phase formation and dielectric phase transition in Ba1-x CaxTi0.6 Zr0.4O3 solid solution, J. Phys. Chem. Solid 67 (2006) 2257–2262.

[9] M.-S. Yoon, S.-C. Ur, Effect of A-site Ca and B-site Zr substitution on dielectric properties and microstructure in tin-doped BaTiO3–CaTiO3 composites, Ceram. Int. 34 (2008) 1941–1948.

[10] E. Aksel, J.L. Jones, Advances in lead-free piezoelectric materials for sensors and actuators, Sensors 10 (2010) 1935–1954.

[11] G. Shirane, R. Newnham, R. Penisky, Dielectric and phase transitions of NaNbO3 and Na,KNbO3, Phys. Rev. Lett. 96 (1954) 581–588.

[12] Chen, X., Ruan, X., Zhao, K., He, X., Zeng, J., Li, Y., ... & Li, G. (2015). Low sintering temperature and high piezoelectric properties of Li-doped (Ba, Ca)(Ti, Zr) O3 lead-free ceramics. Journal of Alloys and Compounds, 632, 103-109.

[13] Hunpratub, S., Maensiri, S., & Chindaprasirt, P. (2014). Synthesis and characterization of Ba0. 85Ca0. 15Ti0. 9Zr0. 1O3 ceramics by hydrothermal method. Ceramics International, 40(8), 13025-13031.

[14] Kimura, T., Dong, Q., Yin, S., Hashimoto, T., Sasaki, A., & Sato, T. (2013). Synthesis and piezoelectric properties of Li-doped BaTiO3 by a solvothermal approach. Journal of the European Ceramic Society, 33(5), 1009-1015.

[15] Liu, X., Zhu, M., Chen, Z., Fang, B., Ding, J., Zhao, X., ... & Luo, H. (2014). Structure and electrical properties of Li-doped BaTiO3–CaTiO3–BaZrO3 lead-free ceramics prepared by citrate method. Journal of alloys and compounds, 613, 219-225.