The influence of microstructure, crystal structure and phase composition of selected ABO_3-type materials developed for electrochemical energy conversion

Sherly Novia Sari, Dariusz Zientara, Paweł Nieroda, Radosław Lach and Paweł Pasierb*

AGH University of Science and Technology, Faculty of Materials Science and Ceramics,
al. Mickiewicza 30, 30 – 059 Kraków, Poland
*corresponding author: ppasierb@agh.edu.pl

INTRODUCTION

The growing demand for energy in the world is generating interest in new energy sources and methods of energy storage. Several proposed solutions take into account ecological aspects and are often based on electrochemical basis. Such solutions and devices are for example fuel cells based on the ABO_3-type protonic ceramic conductors as electrolytes and the clean hydrogen as fuel. Among these materials, barium cerium oxide, $BaCeO_3$, crystallizing in perovskite structure exhibits relatively the highest protonic conductivity in this group of ionic conductors. The development of such materials properties used for the fuel cell construction involves proper selection of the chemical composition of electrochemical device components: electrodes, electrolytes, separators, connectors, etc., but also the microstructure manipulation which often has a strong influence on the basic and functional properties of the material. This microstructure modification may be achieved by the proper selection of the material preparation method and process conditions. Also, the thoughtful selection of the chemical composition may additionally alter the crystal structure, phase composition, microstructure or electrical properties thus leading to the synergistic effects in the materials properties optimization.

In this work we demonstrate the impact of the chemical composition and the synthesis and sintering method and conditions and on the selected fisicochemical and electrical properties of $BaCeO_3$-based protonic conductors.

RESULTS AND DISCUSSION

We have applied a modification of material properties using different approaches: by formation of solid solutions with $BaZrO_3$, by aliovalent doping using Y and Yb, also with the use of co-doping strategy. We have tested the possibility of formation of composites by introduction of various modifier phases based on the Ba-Ce-Y-Si-P-O glassy-crystalline system into the $BaCe_{0.9}Y_{0.1}O_3$ host material using various preparation methods: mechanical homogenization or impregnation in solution. We have also employed and compared different sintering methods: free sintering of pellets, Spark Plasma Sintering (SPS) or Hot Pressing (HP) under controlled conditions.
The obtained materials were characterized and examined using X-ray diffraction (XRD) and scanning electron microscopy (SEM) techniques. The electrical conductivities of the samples were tested in dry air, wet air, and 5 vol% H_2 in Ar at temperatures ranging from 200 °C to 740 °C using Electrochemical Impedance Spectroscopy (EIS) technique.

The analysis of the obtained results allowed to determine the influence of the chemical composition and preparation method on the phase composition, structure, microstructure and electrical properties of the prepared materials. The mutual correlations were found and discussed.

CONCLUSION

The improvement of selected properties for some systems investigated indicates that the use of particular modifications can be a promising way towards the $BaCeO_3$ based protonic conductors with improved properties.

ACKNOWLEDGMENTS

The financial support of the program “Excellence Initiative – Research University” for the AGH University of Krakow, grant No. 501.696.7996, grant ID: 10646 is gratefully acknowledged.