

Playing with High Temperature Proton Conducting Materials for Application in Intermediate Temperature Solid Oxide Fuel Cells (IT-SOFCs)

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Abstract – To couple the best properties of barium zirconate and barium cerate based electrolytes, $\text{BaCe}_{0.8-x}\text{Zr}_x\text{Y}_{0.2}\text{O}_{3-\delta}$ compounds have been produced and conductivity measurements were performed as a function of Zr content. Comparing the electrical results and the chemical stability of the compounds, the proton conductor electrolyte which best comprises good electrical performance and chemical stability has been identified. In a different way, these two properties have been combined together in a single electrolyte protecting a pellet of Y-doped barium cerate with a thin dense layer of $\text{BaZr}_{0.8}\text{Y}_{0.2}\text{O}_{3-\delta}$ grown by pulsed laser deposition.

Proton conduction in doped perovskite oxides has been the subject of extensive investigation because of their potential application as electrolytes in intermediate temperature solid oxide fuel cells (IT-SOFCs). High temperature proton conductors (HTPCs) having perovskite-type structure, such as doped BaCeO_3 , SrCeO_3 , BaZrO_3 , and SrZrO_3 , show proton conductivity in the intermediate temperature range (300-700°C) when exposed to hydrogen and/or water vapor containing atmospheres. Among this class of materials, doped BaCeO_3 shows high proton conductivity, but it is not chemically and mechanically stable, reacting with acidic gases (i.e. CO_2 and SO_2), and water vapor. On the other hand, BaZrO_3 -based materials exhibit excellent chemical stability, but their total proton conductivity is too low for practical use.

In this work different ways of coupling chemical stability and good electrical performance in a HTPC electrolyte were investigated. Using a wet chemical synthesis method, solid solutions between Y-doped barium cerate and Y-doped barium zirconate (namely $\text{BaCe}_{0.8-x}\text{Zr}_x\text{Y}_{0.2}\text{O}_{3-\delta}$, BCZYx) have been produced. From BCZYx powders, dense pellets were fabricated and their electrical properties in terms of electrical conductivity and fuel cell performance were evaluated.

The best properties of doped barium cerate and barium zirconate were also coupled in a different way, fabricating a bilayer electrolyte by means of pulsed laser deposition (PLD) technique. Dense pellets of $\text{BaCe}_{0.8}\text{Y}_{0.2}\text{O}_{3-\delta}$ (BCY) were protected against reaction with CO_2 or water vapor by a thin dense layer of $\text{BaZr}_{0.8}\text{Y}_{0.2}\text{O}_{3-\delta}$ (BZY) grown by PLD. Chemical stability tests showed that the BZY thin layer was effective in preventing BCY reaction with CO_2 . Electrical conductivity and fuel cell performance were investigated. Figure 1 shows the power density output obtained for the BZY-BCY bilayer and the BZY electrolyte, both 1 mm thick, in the same experimental conditions (700°C, flowing H_2 at the anode and air at the cathode side). The bilayer electrolyte, maintaining the same chemical stability of BZY, was able to produce a power density more than 5 times larger than the BZY electrolyte.

Finally, we tried to overcome to high resistivity to proton migration of BZY electrolyte reducing its thickness as much as possible. By means of pulsed laser deposition a thin BZY electrolyte was fabricated on a supporting anode. Fuel cell tests showed promising results.

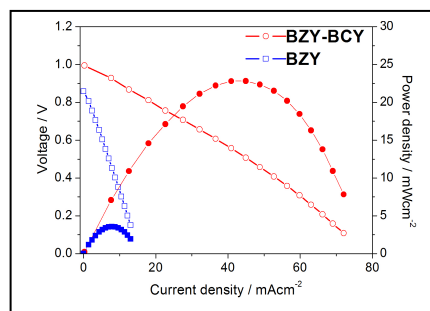


Figure 1: IV curves and power density output of the BCY-BZY bilayer and BZY based cells at 700°C

Reference

[1] K. Katahira, Y. Kohchi, T. Shimura, H. Iwahara, Solid State Ionics, 138 (2000) 91 –98.