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IONIC AND ELECTRONIC CONDUCTIVITY OF 3 mol% Fe_2O_3-SUBSTITUTED CUBIC YTTRIA- AND SCANDIA- STABILIZED ZrO_2

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Introduction

Intermediate temperature solid oxide fuel cells (IT-SOFCs) are expected to operate at temperatures between 600 and 800 °C. To reach this range of temperature, new ceramic electrolytes with high ionic conductivity and negligible electronic conductivity under reducing conditions are required. Materials based on zirconium oxide stabilized by yttrium oxide (YSZ) show low electronic conductivity in both oxidizing and reducing atmospheres [1]. However they have some disadvantages such as a high sintering temperature ($T \geq$ 1600 ºC) and a low chemical stability in wet atmosphere [2]. Scandia-stabilized zirconia (ScSZ) electrolytes exhibit the highest ionic conductivity among all ZrO_2-based materials [3]. However co-doping is necessary to stabilize the cubic modification [4].

In this work we investigated the effect of the addition of a small amount of iron oxide (3 mol %) to the binary systems $(ZrO_2)_{0.90}$-$(Y_2O_3)_{0.10}$ and $(ZrO_2)_{0.90}$-$(Sc_2O_3)_{0.10}$ by substituting Y^{3+} and Sc^{3+} by Fe^{3+} respectively. The aim of this contribution is to present the bulk and total conductivity of these compounds as well as the electronic conductivity as a function of temperature (500 < T < 750 °C) and oxygen partial pressure ranging from 10^{-25} to 1 bar.

Experiments

The powders of $(ZrO_2)_{0.90}(Y_2O_3)_{0.07}(Fe_2O_3)_{0.03}$ and $(ZrO_2)_{0.90}(Sc_2O_3)_{0.07}(Fe_2O_3)_{0.03}$ have been prepared by precipitation of cation hydroxides following the procedure previously described [5]. Impedance spectroscopy technique has been used to determine the bulk conductivity and the total conductivity of the sintered samples in the temperature range from 150 °C to 500 °C. The electronic conductivity has been carried out by using the Hebb-Wagner polarisation technique with a blocking Pt microelectrode as suggested by S. Lübke and H. D. Wiemhöfer [6].

Results and Discussion

It is shown that the co-doping of YSZ and ScSZ by iron oxide stabilizes the cubic phase and decreases the sintering temperature of the compounds. Further, the stability of the cubic phase has been greatly enhanced at room temperature under wet atmosphere. The total conductivity has been slightly decreased by the iron doping but remains highly acceptable for IT-SOFCs, as shown in Fig.1.

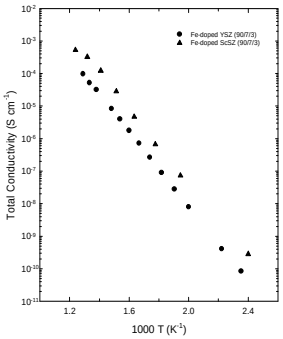

Fig. 1. Total conductivity as a function of inverse of temperature

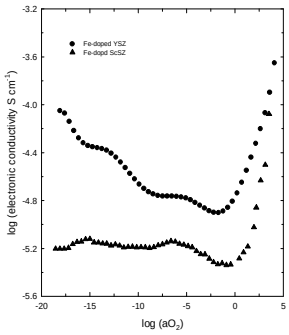

Fig. 2. Electronic conductivity as a function of oxygen activity at 750 °C

The electronic conductivity as a function of oxygen activity is shown in Fig.2 at 750°C. The investigation has been carried out in a wide range of oxygen activity, $10^{-25} < a_{O_2} < 1$, and from 500 °C to 750 °C. The data of co-doped YSZ and ScSZ will be compared to those of the compounds without iron oxide.

Conclusions

This study demonstrates that the addition of a small amount of Fe_2O_3 decreases the sintering temperature and increases the stability of the compound without increasing the electronic conductivity.

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