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Fabrication of highly textured Y-doped barium zirconate thin films by pulsed laser deposition for bulk conductivity direct measurement

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Abstract – Highly textured thin films of Y-doped barium zirconate were grown by pulsed laser deposition (PLD). Using different single crystal substrates it was possible to obtain several depositions with different degree of crystallographic order. A complete structural, morphological and chemical characterization was performed by means of X-ray diffraction (XRD), scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The charge transport mechanism was investigated by electrochemical impedance spectroscopy in different gaseous environments. Extremely high values of conductivity for proton migration were measured for the highly textured depositions in the temperature range of interest for intermediate temperature solid oxide fuel cells (IT-SOFCs).

Y-doped barium zirconate is a pure proton conducting electrolyte. In spite of its good chemical stability in fuel cell operating environment, the conductivity of this material in form of sintered pellets is too low for practical utilization in the intermediate temperature range (400 - 700°C). Its difficult sintering req uires very high temperatures (above 1700°C) leading anyhow to relatively small average grain size (< 1 μm). The poor conducting properties of grain boundary regions accounts for its low conductivity.

Kreuer [1,2] claimed that BZY bulk grain conductivity can be very high and showed high conductivity for BZY single crystals at low temperatures. However, up to now, no direct BZY grain conductivity measurements can be found in the literature at temperatures above 150°C.

To fill this gap, highly textured BZY thin films were grown by PLD. The use of different deposition substrates allowed obtaining films with different degree of crystallographic order and compare their conducting properties with the typical sintered pellets of the same material. XRD, SEM (Figure 1), and XPS analysis demonstrated that these depositions showed the suitable characteristics to obtain direct access to BZY grain conductive properties. The EIS measurements reported in this work (Figure 2) extend the knowledge on proton migration though BZY in the temperature range of interest for IT-SOFCs.

Extremely high conductivity values, up to 0.1 S/cm^2 at 500°C, were measured. Taking into account the very good chemical stability in fuel cell operation of this material, these films can be considered among the best performing solid electrolyte ever developed for fuel cell applications.

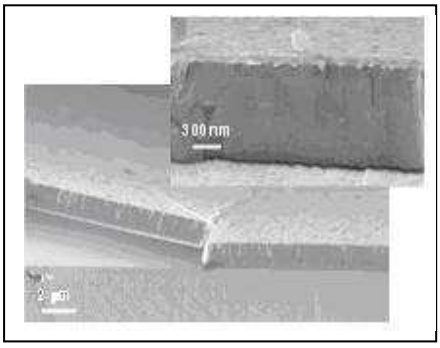

Figure 1: SEM micrograph of BZY prepared by PLD on MgO substrate.

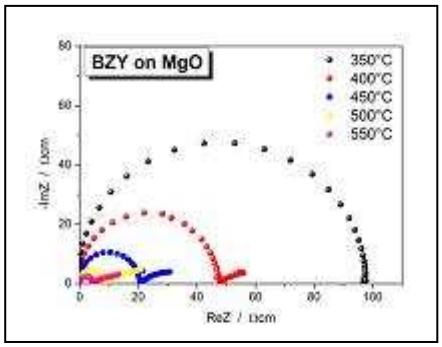

Figure 2: EIS measurements of the BZY film in wet hydrogen at different temperatures.

References

[1] K. D. Kreuer, Solid State Ionics, 25 (1999) 285-302.
[2] K. D. Kreuer, Ann. Rev. Mater. Res., 33 (2003) 333-359.