Growth and electrical properties of nanostructured ytterbium stabilized zirconia thin films

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Introduction: Zirconia based thin films are used on devices where the ionic conductivity it is of prime importance such as its role as the working electrolyte for solid oxide fuel cells. For these applications the deposition of smooth, homogeneous and dense films is required.
Nowadays there are scarce reports of ytterbium stabilized zirconia (YbSZ) thin films despite has been reported to have a higher conductivity than the commonly used yttria stabilized zirconia (YSZ). Discussions of recent research suggest that electrical transport in nanocrystalline thin films is enhanced resulting of a remarkable change on transport properties.
In this work, we investigate the deposition parameters to obtain nanocrystalline microstructures of YbSZ thin films with ultrasonic spray pyrolysis. We report structural and electrical properties to explore their potential as materials for electrochemical devices.

Experimental: Firstly, we present our results on the preparation by ultrasonic spray pyrolysis using metallo-organic precursors. The morphology and structure properties of films were studied by X-ray diffraction, scanning and transmission electron microscopy, atomic force microscopy and ellipsometry.
We used AC measurements in the frequency range 5-13MHz to investigate the electrical properties. A parallel pattern of two electrodes was sputtered on the film surface to be used as electrodes.

Results and discussion: Thin films were prepared in a custom made setup and a systematic study of growth parameters was made in order to obtain nanostructured, smooth, homogeneous and dense materials. Fig. 1 shows typical XRD pattern for deposited films with different ytterbium contents. Phase obtained after the deposition was confirmed as cubic zirconia (ICSD:062462) with no other secundary phase visible. The ytterbium to zirconio ratio of thin films produced under varying dopant amount was measured by EDS. This analysis showed that Zr and Yb in the film were almost in the same proportion than in the started solution. The crystallite size calculated using Scherrer's equation were between **6-10 nm**.

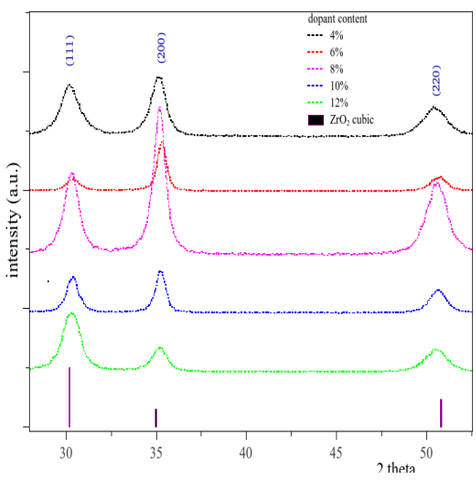

Figure 1. XRD of YbSZ thin films with different dopant content

AFM studies of surface in tapping mode reveals small nanometric grains and close contact between theirs without pores and relativity homogeneous particle size distribution. RMS roughness was also obtained from AFM we found values around 1.30 nm. These results are very important for applications like solid electrolytes. See figure 2.

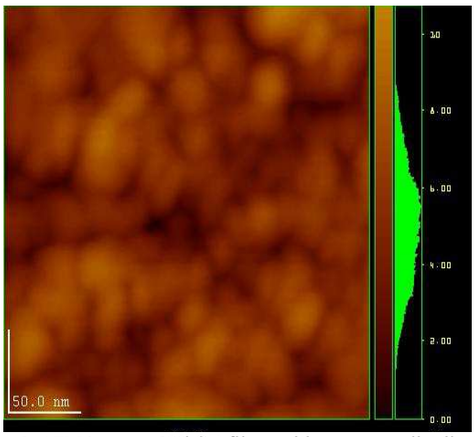

Figure 2. AFM images of YbSZ films with a narrow distribution of grain sizes. The roughness (Rq) is around 1 nm .

AC measurements were carried out for temperatures between 150- 450°C. Figure 3 shows conductivity in air for YbSZ with 10 mol percent of doping. The activation energy for grain and grain boundaries was reduced comparing with similar reports. It is related to small size of grains and the close boundaries. This films are good candidates for electrolytes in solid oxide fuel cells.

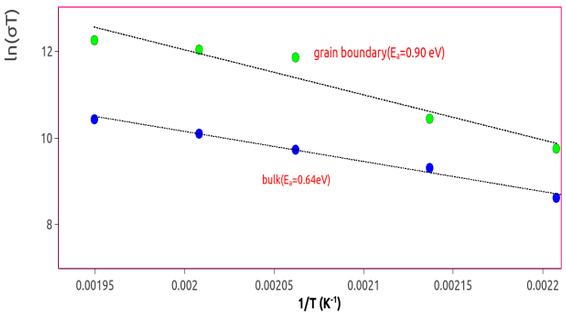

Fig. 3. Arrhenius plots for grain (Ea= 0.64 eV) and grain boundary (Ea=0.9 eV) (ionic conductivity)

Conclusions: We have prepared nanostructured thin films of ytterbium stabilized zirconia using ultrasonic spray pyrolysis technique. This technique produces thin films with excellent properties: dense, smooth and crack free. After evaluate electric properties these materials are promising candidates for electrochemical devices.

References:

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