NANOSTRUCTURED CERIUM DIOXIDE THIN FILMS BY MOCVD: INFLUENCE OF THE SUBSTRATE NATURE AND PROCESSING PARAMETERS

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Cerium dioxides (CeO_2) <100>oriented buffer layers have been grown by MOCVD from Ce(III) 1,1,1,5,5,5-hexafluoro-2,4-pentanedionato diglyme adduct, on different substrates: YSZ (100)[1], TiO_2 (001) and Hastelloy C276[2], i.e. epitaxial (5% and 17% lattice mismatch, respectively for YSZ and TiO_2) and non-epitaxial substrates. The contribution of substrate nature and processing parameters on the growth of CeO_2 films has been deeply investigated. The precursor decomposition kinetics and growth kinetics have been studied on all the substrates as a function of the deposition parameters.

The CeO_2 (100) heteroepitaxial films grow over YSZ(100) (figure 1) at low temperatures (450°C) and become of real single crystal quality at higher deposition temperature (750°-1000°C). Typical pole figure patterns (insert in figure 1) consisting of four poles with 90° φ spacing have been found, pointing to a cube on cube epitaxial growth.

The significant lattice mismatch (about 17%) between <100>oriented CeO_2 film and TiO_2 (001) substrate, points to a critical epitaxial growth. The epitaxial growth of <100> oriented CeO_2 films on TiO_2 (001) has been tailored by varying deposition parameters and monitored by a complete structural characterisation. θ-2θ scans (figure 2) and X-ray pole figures show that <100> CeO_2 films with good crystallinity can be deposited on (001) TiO_2 substrates in the 450-750°C temperature range. In particular, in the case of CeO_2(100)/TiO_2(001) system, the (100) orientation, apparent even at 450°C, develops to a near perfect triaxial alignment at 750°C with $\Delta\phi=2$ (insert in figure 2). CeO_2 films, grown at deposition temperatures higher than 750°C, show a <111> orientation. Pole figures of the (200) reflection show twelve maxima indicating the presence of at least two in-plane variants.

The evolution of fiber texture, upon varying the growth conditions, has been interpreted in terms of surface mobility and lattice matching.

A typical θ-2θ X-ray diffraction pattern (figure 3) of a CeO_2 film produced at 450°C on Hastelloy shows only the CeO_2 (200) and (400) reflections, and the FWHM of the (200) reflection rocking curve (about 8°) points to an effective <100> CeO_2 fiber texturing on a nonepitaxial and no-rolled substrate. Experiments at higher (>450°C) deposition temperatures point to the formation of randomly oriented films. The SEM cross-sectional image shows a highly columnar microstructure. This morphology can be rationalized on the basis of the Mochvan-Demchishin model.[3-4]

Finally, present data show that texturing and/or epitaxy of CeO_2 films is very sensitive to the deposition temperature, thus oriented and/or epitaxial <100> CeO_2 films can be grown on different substrates by MOCVD technique.

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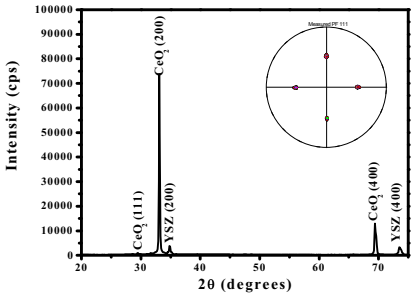

Figure 1. XRD spectrum of a CeO_2(100) film deposited on YSZ(100) and its pole figure (insert).

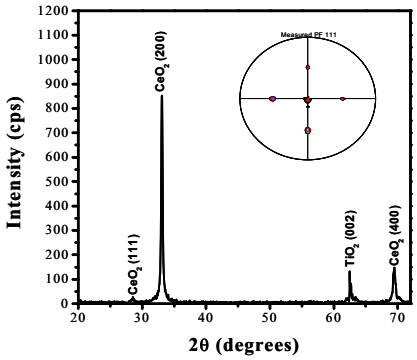

Figure 2. XRD spectrum of a CeO_2(100) film deposited on TiO_2(001) and its pole figure (insert).

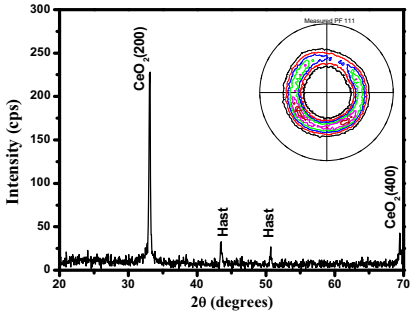

Figure 3. XRD spectrum of a CeO_2(100) film deposited on Hast and its pole figure (insert).