Synthesis of porous ZnO films on silicon substrates by thermal oxidation and the temperature effect

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In the present work we realized the synthesis and characterization of porous ZnO films using a two-stage process by thermal oxidation using a bilayer precursor film (ZnO/Zn) consisting of a Zn film covered with a ZnO nanofilm formed on silicon substrates is reported. The Zn films of 50 nm were grown by DC sputtering method at 300K. In the first stage bilayer precursor films (BPF) of ZnO/Zn were produced by growing a ZnO nanofilm on Zn films by thermal oxidation at 350 °C by 30 min in N_2 atmosphere containing 5 ppm of O_2, and in the second stage the BPFs were oxidized at three diferentes temperatures 600°C, 700°C y 800°C. The produced porous ZnO films were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and Photoluminescence (PL). The XRD measurements confirm that the porous films grown by this method have good crystalline hexagonal wurtzite structures. The formation of pores of ZnO was observed in the range of 40- 100 nm were obtained as the temperature decreased

INTRODUCTION

Nowadays many works have been attempted to fabricate nanosized materials with a controllable morphology, shape and sizes due to their new fascinating and exceptional properties and potential uses for applications in nanodevices and functional materials. Among all nanomaterials, zinc oxide has been one of the most intensively studied metal-oxide semiconductor materials in recent years because of its low toxicity, good chemical and thermal stability, good biocompatibility, large specific surface area and high electron mobility.

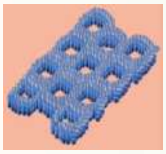

Fig. 1. *Scheme of porous thin films*

EXPERIMENTAL SECTION

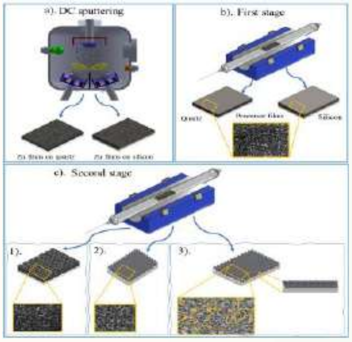

Fig. 2 *Scheme summarizing the experimental procedure of this research. (a) Zn sputtering, (b) first stage of TO and (c) second stage of TO*

DISCUSION AND RESULTS

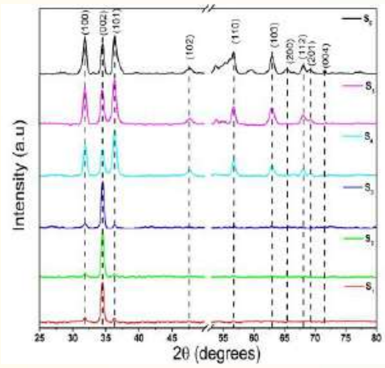

Fig. 3 *XRD patterns of zinc oxide films deposited on quartz and Si substrates thermally oxidized at different temperatures.*

Table 1. *Summary of structural information about XRD pattern for ZnO deposited on quartz and Si substrates thermally oxidized at different temperatures obtained from the diffraction patterns from the (002) plane.*

Sample	ZnO peak position (°)	FWHM of the intensity, β (rad)	Crystalline Size (nm)
S_1	34.48	0.47	17.55
S_2	34.52	0.49	16.82
S_3	34.52	0.49	16.88
S_4	34.52	0.61	13.56
S_5	34.48	0.59	14.16
S_6	34.50	0.51	16.18

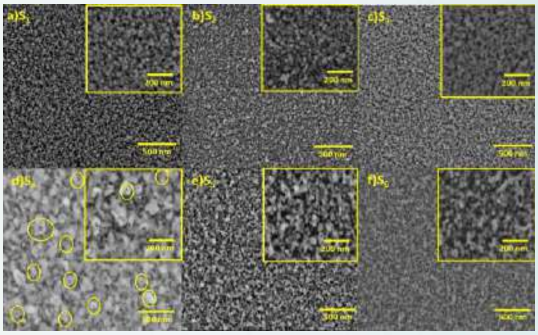

Fig. 4 *Images of the morphology presented on the surface of zinc oxide films deposited on quartz substrates at 600 (a), 700 (b), 800 °C (c) and silicon 600 (d), 700 (e), 800 °C (f) after oxidation.*

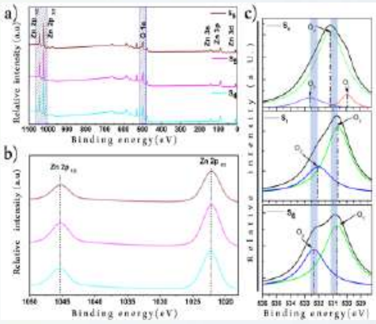

Fig. 5 *The comparison between XPS spectra acquired from Zinc Oxide on Si substrate after oxidation at 600 °C (S_4), 700 °C (S_5), and 800 °C (S_6) in (**a**) survey, 1050-1020 eV range (**b**) and (**c**) 536-528 eV range.*

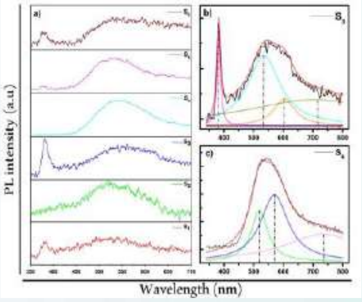

Fig. 6 *a) PL spectrum of porous ZnO films with temperature variation on quartz and Si substrates, b) PL spectrum of ZnO film in quartz annealed at 800 ° C (S_3), c) PL spectrum of ZnO film in Si annealed at 600 ° C (S_4).*

CONCLUSIONS

- A strong influence from the substrate (Si or quartz) was observed for growing weather ZnO nanoporous films or ZnO nanoporous film with hexagonal nut-like structures.
- The XPS spectroscopy allowed the analysis of the sample at atomic level, observing that the number of Vo increases in the sample that presents ZnO nanoporous film with hexagonal nut-like structures

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