Microstructural Characterization and Properties of High Quality ZnO Based Thin Films

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Better performance of ZnO thin films in the degradation of organic molecules have stimulated many researches to further explore the properties of this oxide in many photocatalytic reactions. However, its use is limited due to its relatively high band gap and to the dissolution of the film in aqueous media; since ZnO has a non-negligible dissolution constant in water. ZnO doped with transition metal ions has been studied as a promising way for improving photocatalysis, extending their response from ultraviolet to visible region. On the other hand, ZnO based thin films have a great potential in many technological applications, e.g. spintronics, transparent conducting electrodes, biocompatible materials, solar cells, light emitting diodes and lasers in the ultra violet region. In this work, we report the synthesis, microstructural characterization, optical and photocatalytic properties of undoped, and Co doped ZnO thin films. They were deposited by aerosol assisted chemical vapour deposition method onto borosilicate glass and Si substrates, using the set up described elsewhere [1]. The films had high quality, they were uniform, well adhered and non-light scattering. Co content was varied from 1 to 25 at. % in solution. The microstructure of the films was characterized by grazing incidence X-ray diffraction (GIXRD), field emission scanning electron microscopy (SEM), and high resolution transmission electron microscopy. Composition of the samples was verified by EDS analysis. Film stoichiometry was close to ideal ZnO, and doped films maintain approximately the same Co/Zn ratio in film as in solution. All the films were polycrystalline, single phase with a structure of Wurtzite type [2]. No other phases corresponding to metallic Co, other oxides or compounds were detected by GIXRD. The microstructure of ZnO thin films depended on the amount of dopant material incorporated. Figure 1 shows SEM micrographs of the surface morphology of undoped and Co doped films; it is shown a drastic change in grains shape and size. Average grain size was estimated from measurement of several AFM images of the surface of the films. The optical properties were determined from total reflectance and transmittance spectra in the UV-VIS-NIR interval. Results were analyzed to determine the optical constant and band gap of the films. Optical absorption spectra showed characteristic absorption edges around 568, 616 and 658 nm; these are correlated with d-d transitions of Co^{+2} ions [3]. The optical band gap depended on the content of dopant; it decreased with the increase of Co concentration. Photocatalytic degradation of methylene blue was performed, Co doped films showed better activity than ZnO films. Another advantage to the introduction of Co in the microstructure was the diminution of the solubility in water of the doped film. Carrier density and mobility were determined by Hall measurements.

References

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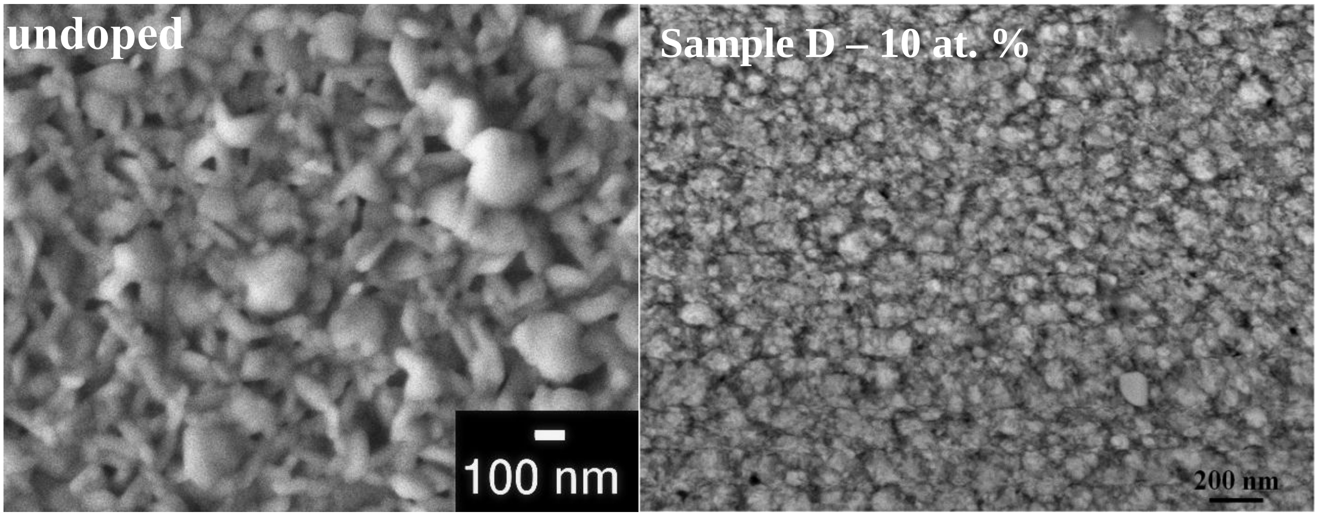

FIG. 1. Secondary electron SEM micrograph, showing the surface morphology of typical undoped and Co doped ZnO thin films.