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ZnO AND $Zn_{0.99}Co_{0.01}O$ CRYSTALLITES GROWN USING CHEMICAL METHOD

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Abstract- Crystallites of ZnO and $Zn_{0.99}Co_{0.01}O$ have been grown on glass substrate by wet chemical decomposition of zinc/cobalt-amino complexes in aqueous medium. Structural properties of grown crystallites were investigated by the help of X-ray Diffractometer, Scanning Electron Microscope and Energy Dispersive X-ray spectroscope.
Keywords- Doped ZnO; Different morphologies

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Introduction

During the recent years ZnO has received tremendous attention as photo-catalysts [1], luminescent materials [2], transparent electron conductors [3] and solar cells [4]. In most of these applications, ZnO is doped for enhanced or added functionality. Transition element (Mn, Co, Fe, etc.) doped ZnO is a potential candidate for diluted magnetic semiconductors [5-7], where concentration of charge and spin can be controlled independently by changing the concentrations of dopant elements. Among other oxide-based DMS, ZnO doped with small amount of Co^{2+} (i.e. $Zn_{1-x}Co_xO$), without any modification in the structure has been considerably explored with abundant theoretical and experimental reports of a possible intrinsic room temperature ferromagnetism [3]. However these results remain still debated as some of the groups have reported about either the absence of ferromagnetism [4] or the presence of segregated Co impurities [5] in these compounds. The previous reports on chemical deposition method of $Zn_{1-x}Co_xO$ thin crystallites show that the morphology of the crystallites having rod structure is strongly dependent on the experimental conditions, such as solution concentration, pH of the solution, growth temperature and the substrate preparation [8].

Experimental

The starting materials to synthesize ZnO and $Zn_{0.99}Co_{0.01}O$ crystallites were $Zn(NO_3)_2.H_2O$, $Co(NO_3)_2.H_2O$ and Hexamethylenetetramine (HTMA) which were separately dissolved in water to get 0.1M solution of each. Solutions of $Zn(NO_3)_2.H_2O$ and $Co(NO_3)_2.H_2O$ were mixed together in the required stoichiometric ratio so as to achieve 1% Co doped ZnO. The solution of HTMA was then mixed with the above solution in the ratio 1:4. The film growth rate was found to be a sensitive function of bath pH as well as temperature. The critical range of pH value for good quality crystallites was found to be 10.5-11.0. About 25% ammonia aqueous solution was added to adjust the pH of the solution as about 11. The mixture was stirred for about 10 minutes till the transparent solution was obtained. Crystallites of Zinc oxide (ZnO) and Co-doped ZnO have been deposited on glass substrates (micro slides) by wet chemical decomposition of zinc-amino complexes in aqueous medium. The glass substrate was cleaned using ultrasonic cleaner by dipping the substrate in acetone and isopropyl alcohol. The cleaned substrate was tightly held in a holder so that only a requisite area for crystallite deposition was exposed. Thus, the crystallite growth area could be easily varied by adjusting the holder arrangement. The deposited ZnO crystallites were subsequently

annealed in air at 150 ◦C.
The samples were characterized using X-ray diffractometer (XRD: Philips, CuKα radiation), Scanning Electron Microscope (SEM: JEOL, Model: JSM-6390LV) embedded with Energy Dispersive X-ray (EDX: Oxford INCA, Model: DCL-7673) spectroscope.

Results & Discussions

Figs. 1 (a) and (b) show the XRD spectra of the as-prepared crystallites on glass substrate. Three pronounced diffraction peaks were observed at 2θ= 37.07°, 40.20° and 42.40° respectively and attributed to (100), (002) and (101) planes of ZnO. X-ray diffraction indicates that the Co-doped ZnO thus prepared has the pure ZnO wurtzite structure without any significant change in the cell parameters.

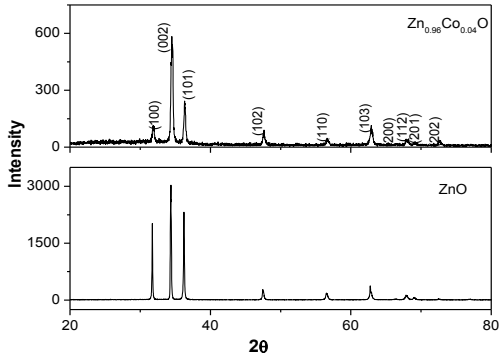

Fig. 1- XRD Pattern of ZnO and $Zn_{0.99}Co_{0.01}O$.

Figures 2 (a) and (b) show the SEM micrographs of crystallite of pure ZnO on glass substrate. The flowers like bundles are composed of rods with the average diameter of one micron. From figure 2 (b), it can be seen that on some parts of the substrate hexagonal rods are oriented almost vertical to the surface having average length of the order of 10 microns.. Figure 3 shows the micrograph of thick crystallites of $Zn_{0.99}Co_{0.01}O$. For this composition, a mixed structure consisting of flowers like bundles and spherical clusters like structures are observed. The presence of Co in spherical clusters like structures is confirmed by EDX analysis, but no Co is obtained in the regions of flowers like bundles confirming that Co is not taking part in forming rod shaped structure.

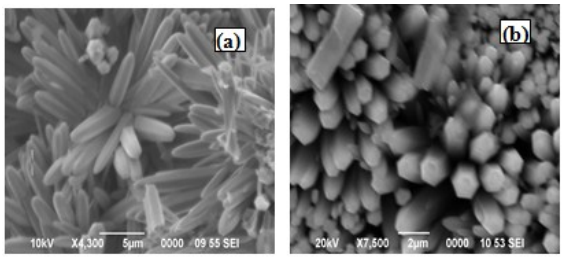

Fig. 2- SEM patterns of (a) flower like bundles (b) micro rods of ZnO

Conclusions

This paper reports the chemical synthesis of crystallites of $Zn_{1-x}Co_xO$ (x=0 & 0.01) on glass substrates under simple and crude conditions, which makes this method promising for large-scale production. The critical range of pH value for good quality crystallites was found to be 10.5-11.0. The XRD results indicate that the synthesized

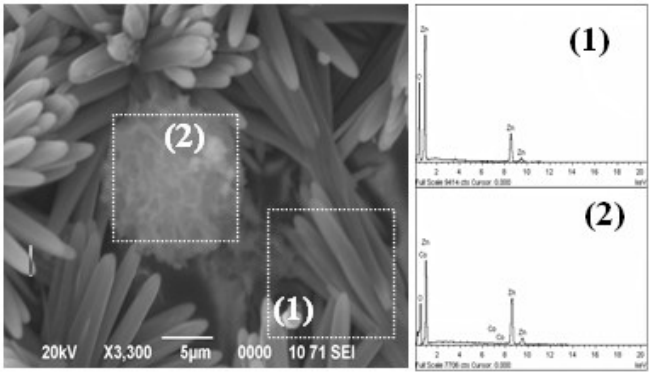

Fig. 3- SEM pattern of $Zn_{0.99}Co_{0.01}O$ crystallites: Plots marked with (1) & (2) show the EDX patterns of respective regions (1) & (2) considered on SEM pattern.

$Zn_{1-x}Co_xO$ crystallites have the pure wurtzite structure without any significant change in the structure affected by Co substitution. The presence of Co in spherical clusters like structures is confirmed by EDX analysis, but no Co is obtained in the regions of flowers like bundles confirming that Co is not taking part in forming rod shaped structure.

Acknowledgements

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