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Effect of substrate temperature on structural and optical properties of reactive dc magnetron sputtered CdZnO thin films

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Abstract

Thin films of ternary cadmium zinc oxide (CdZnO) were prepared on glass substrates by dc magnetron sputtering technique at different substrate temperatures (RT, 100^{o}C, 200^{o}C & 300^{o}C). The structural and optical properties of the films are investigated by glancing angle x-ray diffraction (GAXRD) and UV-vis-NIR spectroscopy measurements respectively. GAXRD pattern confirmed the hexagonal wurtzite structure with a preferred grain orientation in (002) direction for all the samples. The optical studies reveal that, the optical band gap was decreased from 3.25eV to 2.88eV with increase of substrate temperature.

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Keywords: GAXRD; CdZnO thin films; optical band gap; substrate temperature

1. Introduction

Recently, transparent conducting oxides (TCOs) have been applied in many devices such as sensors [1], phototransistors [2], solar cells [3, 4], electromechanical devices and optoelectronic devices [5, 6]. Even though

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several materials such as SnO_2, ZnO, F:SnO_2, In:SnO_2 etc., are proposed for TCO applications, ZnO have attracted great attention because of their high electrical conductivity and optical transmittance [7, 8] over a wide spectral range including the useful UV-vis region and other more interesting features such as low toxicity, relatively low cost and high chemical stability in hazardous conditions [9, 10]. The pure and mixed oxide films of CdO, Cr_2O_3, Al_2O_3, ZnO, SnO_2 and In_2O_3 have been used as window materials in many optoelectronic devices [11]. From these materials, CdZnO is one of the promising candidates in the field of optoelectronics and also for the fabrication of n-type ZnO based devices [12]. Thin films of CdZnO were synthesized by various deposition techniques such as vacuum evaporation [13], spray pyrolysis [14], chemical vapour deposition [15], sol-gel process [16], laser-molecular beam ephitaxy [17], thermal evaporation [18], ion beam sputtering [19], dc and rf magnetron sputtering [20, 21].Among various methods, dc magnetron sputtering offers many advantages for the preparation of TCO films using metal targets where high deposition rates will be obtained on large area substrates and the stoichiometry can be easily controlled. In the present investigation, we report the preparation of CdZnO thin films by dc reactive magnetron sputtering technique and study the effect of substrate temperature on their structural and optical properties.

2. Experimental details

Thin films of CdZnO were deposited on well cleaned corning glass substrates by reactive dc magnetron sputtering technique. The sputtering chamber was evacuated to a base pressure of 8 X 10^{-6} mbar using mechanical-vacuum-air-pump and oil-diffusion-pump. Cd (99.99%) and Zn (99.99%) were used as sputtering targets with 2 inch dia. and 4mm thick. The target-to-substrate distance was fixed at 60mm. High purity argon and oxygen gasses were used as sputtering and reactive gases, respectively. The working pressure for this system was maintained as 3-5 X 10^{-2} mbar. The sputtering current and voltage maintained during the deposition were 250mA and 300-350 V, respectively. Thin films of CdZnO were deposited at different substrate temperature vary from RT to 300^{o}C. The targets were pre-sputtered for 10 min to remove the surface oxide layers on the targets in argon atmosphere. The deposition time was 30 min for all the samples. The thickness of the grown films was measured by the stylus profilometer and is 250 nm. The structural and optical properties of the films were examined by GAXRD and UV-vis-NIR spectrophotometer respectively.

3. Results and discussion

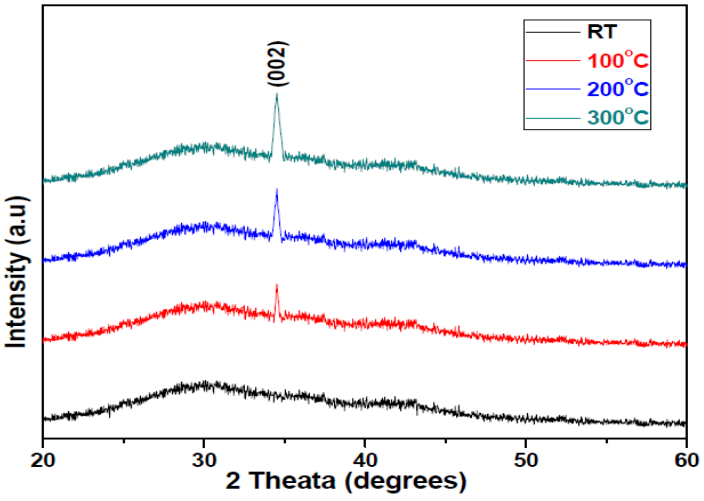

Fig. 1. GAXRD plots of CdZnO thin films at different substrate temperatures (RT, 100^{o}C, 200^{o}C and 300^{o}C).