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Original article

Effect of annealing temperature and doping with Cu on physical properties of cadmium oxide thin films

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ABSTRACT

In this research, pure and copper doped cadmium oxide thin films were prepared by Successive Ionic Layer Adsorption and reaction (SILAR) method using cadmium acetate as the Cd source (cation) and hydrogen peroxide (anion). Optical transmittance is measured by UV–visible spectrophotometer, it is revealed that the copper doping and annealing at 300 °C improves the transmittance of these films. The optical band gap of CdO increased to (2.8 eV) with Cu doping, but it is decreased to (2.4 eV) with annealing. The results show that the pure and doped CdO thin films at annealing temperature of 300 °C have grain size in the range of 19.1 nm and 44.4 nm, respectively.

1. Introduction

The rapidly growing development of nanotechnology is due to the unique properties of nanocrystalline materials in comparison with their large-grained analogs. Cadmium oxide (CdO) is an important semiconductor material for the development of various technologies of solid-state devices [1] (panel display, optoelectronic components, thermally insulating glass, etc.) [2]. Recently CdO has attracted attention as a transparent conducting oxide because of its (i) band gap (~2.5 eV), (ii) high conductivity, (iii) ease in doping, (iv) chemical stability in hydrogen plasma, (v) abundance in nature and no toxicity [3]. Some physical properties of this oxide have been investigated by several authors. Various techniques such as thermal evaporation [4], sputtering [5], solution growth [6], pulsed laser sputtering [7], activated reactive evaporation [8], spray pyrolysis deposition (SPD) [9] and (SILAR) method were employed to prepare thin films of CdO. It was experimentally found that the structural, electrical and optical properties of copper doped cadmium oxide strongly depend on the preparation method and deposition conditions [10]. Transparent conducting oxides (TCOs) have long been a subject of various investigations due to its unique physical properties and applications in commercial devices been successfully used for many applications, including phototransistors [11], gas sensor [12], solar cells [13], liquid crystal displays, IR detectors and anti-reflection coatings [14]. Doping of CdO thin films incorporating various elements such as Sn [15], in [16] F [17] and Al [18] have already been studied.

This paper describes the deposition of pure and copper doped CdO thin films by (SILAR) method. Then investigate the influence of the doping with Cu and annealing at 300 °C on the structural and optical properties of these films.

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2. Experimental details

CdO thin films have been deposited on glass substrates using Successive Ionic Layer Adsorption and reaction (SILAR) method in an aqueous solution of cadmium acetate [($Cd(CH_3COO)_2 \cdot 2H_2O$) 99.99%] (cation) with molarities (0.03 M) and 100 mL (14 M) aqueous ammonia solution. The complexing agent ammonium hydroxide was used to stabilize the crystallite size. The pH of the prepared solution was maintained as 8.5 throughout the deposition process. Other solution was 0.003 M of hydrogen peroxide (anion), as well as double distilled water.

(1) Immersed first in cadmium acetate (0.03 M) and ammonium hydroxide solution for 40 s.
(2) Immersed in quantitative amount of double distilled water in 10 s at 90 °C.
(3) Immersed in 0.003 M of hydrogen peroxide (anion) solution for 30 s.
(4) Cu was prepared by a chemical technique for doping CdO thin film.

1% Cu was added drop by drop until the homogeneous and clear solution was obtained, then the stirring continued for 1 h. This cycle was repeated several times in order to increase the overall film thickness of CdO. The deposited film was subsequently annealed in air at 300 °C for 50 min. The structural measurements were done using optical microscope type (NIKON, ECLIPSE, ME600). For measuring the optical absorption and transmittance of thin films, a double beam (OPTIMA

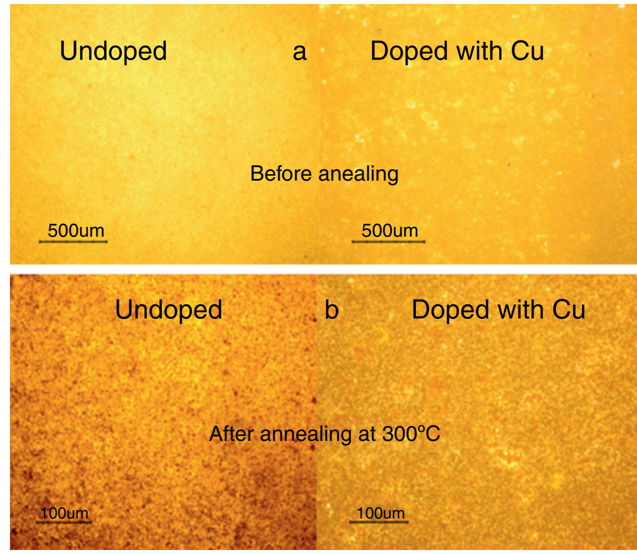

Fig. 1 – Images for CdO (undoped) and CdO: Cu films, before and after annealing at 300 °C.

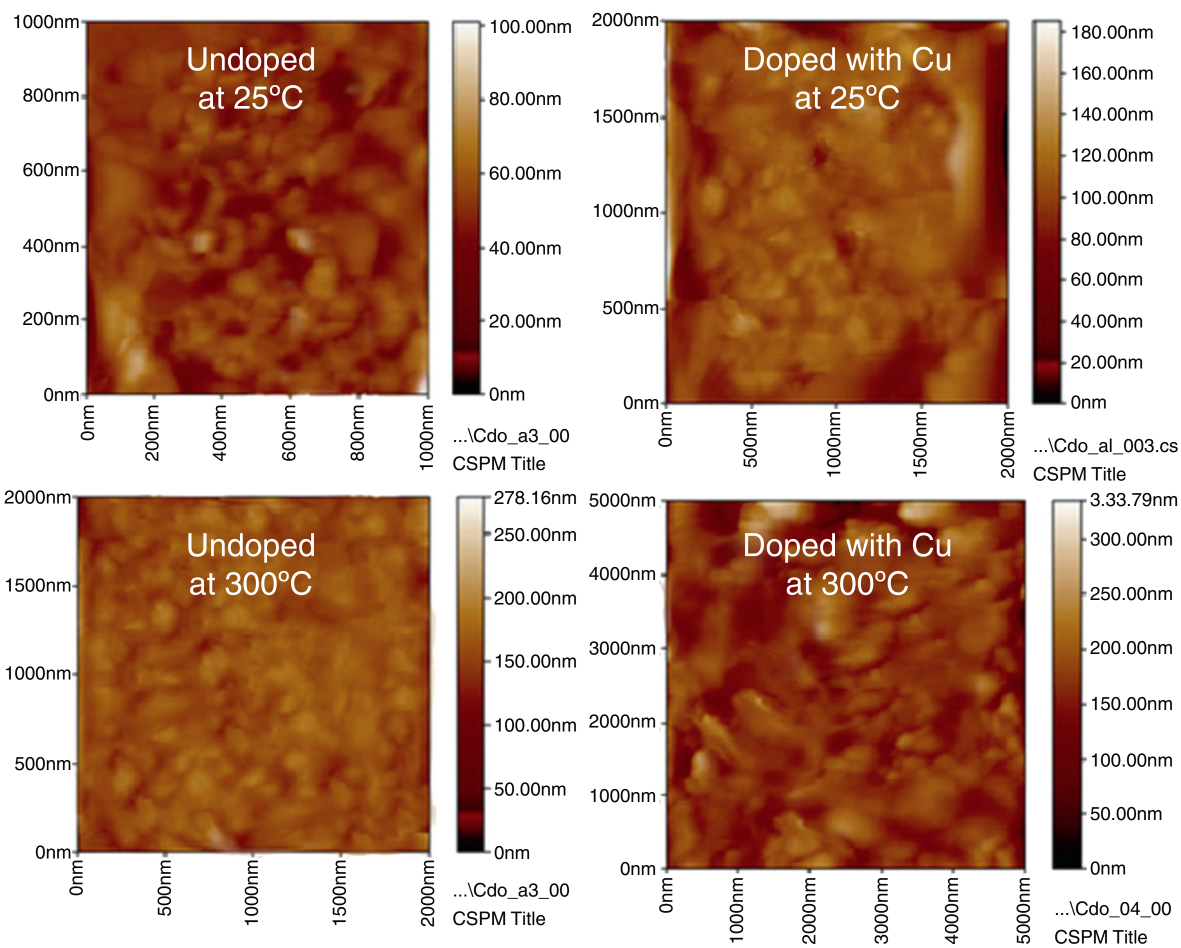

Fig. 2 – AFM images for CdO (undoped) and CdO: Cu films, before and after annealing at 300 °C.