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Electrical parameters of metal doped n-CdO/p-Si heterojunction diodes

P. Umadevi [a], N. Prithivikumaran [b,*]

[a] Department of Physics, Sri Vidya College of Engineering & Technology, Virudhunagar 626005, Tamilnadu, India
[b] Nanoscience Research Lab, Department of Physics, VHNSN College, Virudhunagar 626001, Tamilnadu, India

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ABSTRACT

The CdO, Al doped CdO and Cu doped CdO thin films were coated on p-type silicon substrates by sol–gel spin coating method. The structural, surface morphological and electrical properties of undoped, Al and Cu doped CdO films on silicon substrate were studied. The Ag/CdO/p-Si, Ag/Al: CdO/p-Si and Ag/Cu: CdO/p-Si heterojunction diodes were fabricated and the diode parameters such as reverse saturation current, barrier height and ideality factor of the diodes were investigated by current–voltage (*I–V*)characteristics. The reverse current of the diode was found to increase strongly with the doping. The values of barrier height and ideality factor were decreased by doping with aluminium and copper. Photo response of the heterojunction diodes was studied and it was found that, the heterojunction diode constructed with the doped CdO has larger Photo response than the undoped heterojunction diode.

1. Introduction

Schottky structures such as metal–semiconductor (MS) and metal-insulator–semiconductor (MIS)have an important role in modern electronics. Due to the performance and stability, the MS structures are of great importance to the electronic device applications [1–3]. In recent years, researchers have focused on transparent conducting oxide (TCO) materials because of their potential application specially in the field of optoelectronic devices such as Photo diodes, Solar cells, Photo transistors and Gas sensors [4–6]. Cadmium oxide (CdO) is one of the most important TCO materials which is a n-type semiconductor with a direct band gap around 2.2 eV to 2.5 eV [7,8]. CdO has many attractive properties such as high optical transmittance in the visible region of solar spectrum [9] and low resistivity. Different methods have been adopted to deposit CdO films such as sol–gel [10,11], Spray pyrolysis [12], DC magnetron sputtering [13], Chemical bath deposition [14] etc., Of these methods, the sol–gel spin coating method is simple and economical, and it has facility of stoichiometry control and films with chemical homogeneity can be obtained [15,16] and hence this method was employed to deposit CdO film on silicon substrates in the present work.

There are few reports about heterojunction diode based on CdO. Karatas et al., have reported the effect of illumination on electrical parameters of CdO/p-Si diode [17] and Gupta et al. [18] have reported the effect of temperature on diode parameters of Cu_2O/p-Si heterojunction. In the present work, Ag/CdO/p-Si, Ag/Al: CdO/p-Si and Ag/Cu: CdO/p-Si heterojunction diodes were constructed and their parameters such as ideality factor, barrier height and Photoresponse were studied.

2. Experimental details

2.1. Thin Film deposition

The sol- gel spin coating method was used to deposit the undoped, Al doped and Cu doped CdO films on silicon substrates. The precursor solution for CdO film was prepared by dissolving cadmium acetate of 0.25 M in 75 ml of ethanol and 1 ml of lactic acid is added to it to obtain the clear solution. Similarly by adopting the above process, two more precursor solutions were prepared to obtain Al doped CdO and Cu doped CdO films by adding 6 wt% of aluminium nitrate and 6 wt% of copper nitrate respectively. By using magnetic stirrer the three different solutions were constantly stirred separately at 65 °C for 2 h and kept aging for three days. Prior to deposition p-type silicon substrates were well cleaned to remove dust, grease and metallic impurities from the surface. To remove any oxide present on the surface of the substrate, an acid treatment using a mixture of HF: H_2O in the ratio of 1:10 was given for 30 s. Then the wafers are washed thoroughly in flowing DI water using an ultrasonic bath for 10 min. Finally the substrates were chemically cleaned according to the method based on successive bath of methanol and acetone. These cleaned p-Silicon wafers were used to deposit CdO, Al doped and Cu doped

* Corresponding author.
E-mail address: janavi_p@yahoo.com (N. Prithivikumaran).

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CdO films by sol – gel spin coating method under the following experimental conditions: The coating solutions were dropped on to silicon substrates and then substrates were rotated at 3000 rpm for a spin time of 15 s for each coating. After every coating, the films were dried at 100 °C for 5 min to evaporate the excess solvent and to remove the organic residuals. Eight successive coatings were made on the substrates and the films were finally annealed in the muffle furnace at 400 °C for one hour.

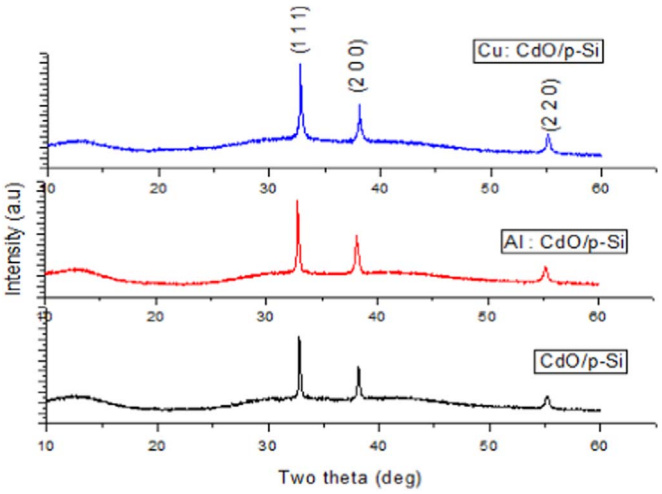

Fig. 1. XRD patterns of undoped CdO, Al doped CdO and Cu doped CdO films on Si substrate.

2.2. Characterization

The CdO thin films were structurally characterized using X-ray diffractometer (PA analytical – PW 340/60 X'pert PRO). The surface morphology of the films was studied by a scanning electron

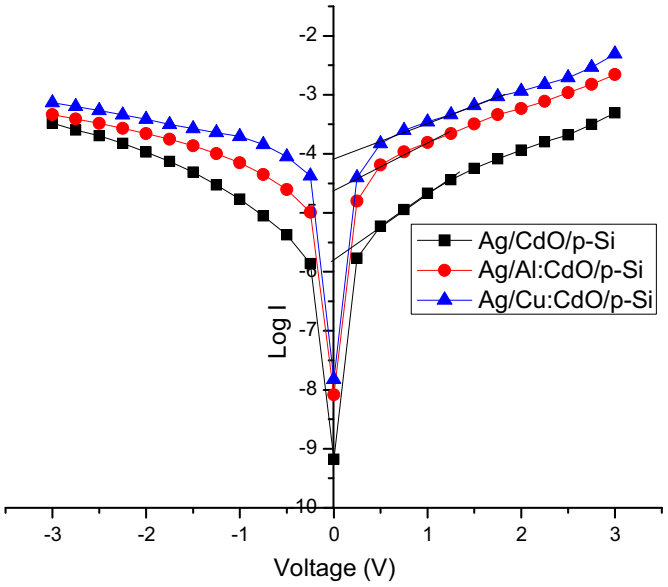

Fig. 3. Log *I–V* characteristics of heterojunction diodes under dark.

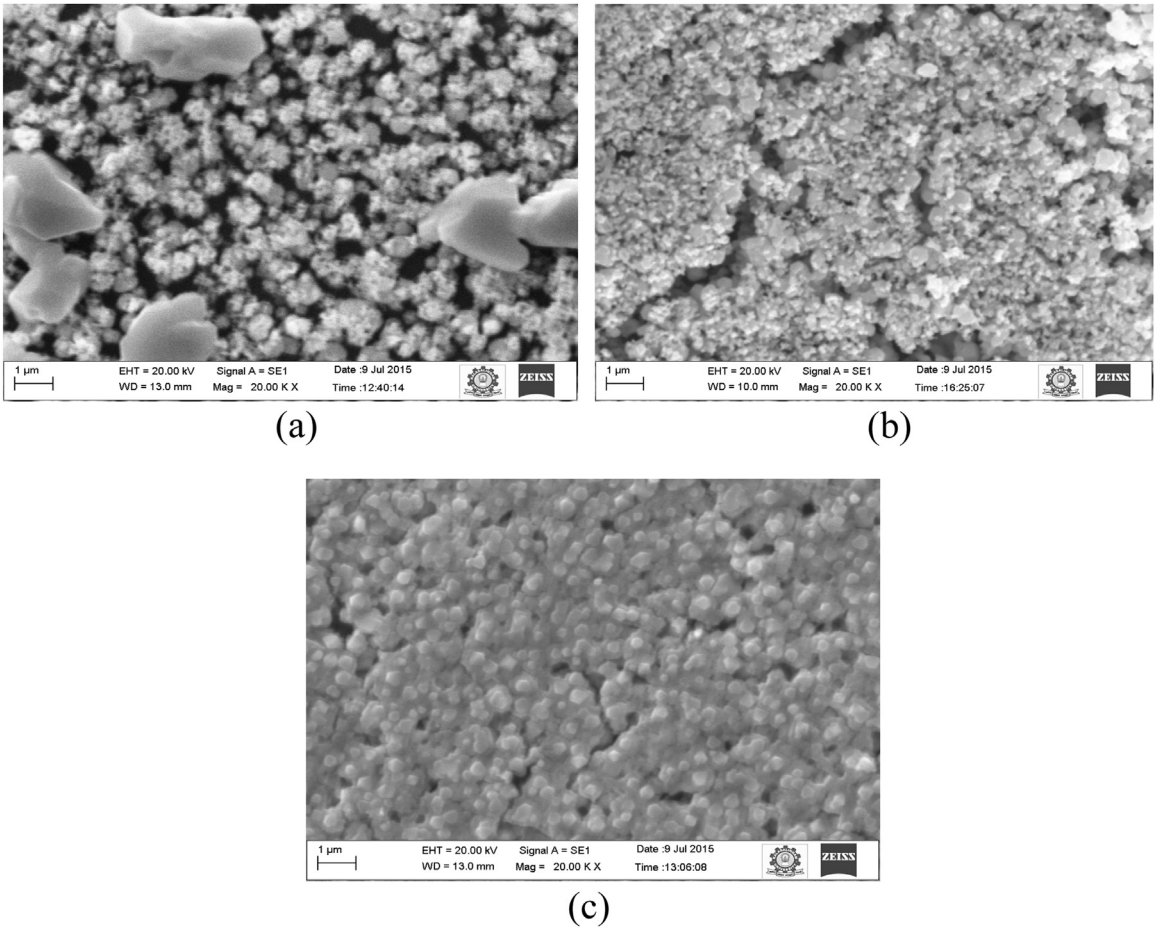

Fig. 2. (a)–(c)-SEM images of undoped CdO, Al doped CdO and Cu doped CdO films on Si respectively.