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Optoelectronic properties of CdO-Si heterojunctions

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CdO-Si heterojunctions were fabricated by depositing CdO polycrystalline thin film on p-type single crystal silicon wafers by chemical bath deposition. The current-voltage characteristics under dark and illumination of CdO/Si devices resemble those of a light sensitive diode. From the CdO/Si diode spectral sensitivity curves (A/W), it has been deduced that CdO films allow good response in the visible and the near infrared and show high sensitivity, in comparison to conventional p-n silicon detectors.

1. Introduction

For many years, transparent conductive oxide layers have been studied extensively because of a wide range of technical applications, for instances as transparent electrodes in photovoltaic and display devices [1], sensors [2] and so on. Cadmium oxide (CdO) is n-type semiconductor that crystallizes in the rocksalt structure (FCC) and presents an optical ban-gap of about 2.2 eV [3]. The CdO films exhibit high transmission in the visible and UV ranges and has high conductivity. These films have been used as transparent contact in $CuInSe_2$ [4] and Si [5] solar cells.

In this work CdO/Si heterojunctions were made using chemical bath deposition, which is a simple and low cost technique for preparing semiconductor thin films, besides low temperature annealing steps. In this paper we report the electrical characteristics of these devices.

2. Experimental details

Cadmium oxide-silicon heterodiodes were fabricated by depositing CdO precursor thin films by chemical bath deposition on p- type CZ silicon wafers (resistivity 1-3 ohm-cm). Prior to the deposition of the CdO film, the silicon wafers were cleaned by a standard process. An aluminum layer was deposited onto back surface of silicon wafer by thermal evaporation and annealed in N_2 atmosphere at 600º C for 10 minutes. Lastly, the above pre-treated samples were again cleaned and etched into HF (10%) solution.

The CdO films were deposited by chemical bath deposition (CBD) according to the procedure described in a previous paper [6]. In the present work, a CdO layer approximately 0.35 μm thick was deposited onto the above pretreated silicon wafer in an aqueous bath comprised of cadmium chloride (0.1M) hydrogen peroxide (0.05 M) and ammonium hydroxide (5.3 M). The bath temperature was kept at 50 ± 3ºC.

Post-deposition thermal treatments on CdO/Si structures were carried out in air atmosphere at 450^0C for 15 minutes. The ohmic contacts of these devices were formed by evaporating indium and aluminum onto the CdO film and the back surface of silicon, respectively. Figure 1 presents a cross-sectional view of CdO/Si heterostructure.

Optical transmission of CdO films deposited on microslide glass were recorded in a UV/Vis Shimadzu 3101 PC spectrometer. The CdO thickness was measured with a Sloan Dektak II profilometer. Dark I-V measurements were done by using a Keithley electrometer automatic system.

The illuminated I-V characteristics were measured under a tungsten-halogen lamp light. The spectral sensitivity was measured by means of a 1200 lines/mm diffraction grating attached to monochromator. This system was calibrated with a (0.5 cm^2) commercial silicon photo-detector.

3. Results and discussion

In a previous paper [6] we have reported our results about the preparation and characterization of chemically deposited CdO films. The as-deposited film prepared by CBD is a high resistivity (10^6 10^7 ohm-cm) CdO_2 polycrystalline film, which becomes low resistivity (10^{-3} ohm-cm) CdO after an annealing treatment [6].

Figure 2 shows the transmittance of a CdO film about 0.35 μm thickness deposited on microslide glass annealed at 450º C for 15 minutes. This film has a sheet resistance of approximately 30 ohm/ € and exhibits high transmission for wavelengths above 600 nm. Films with these characteristics were used for preparing de CdO/Si diodes.

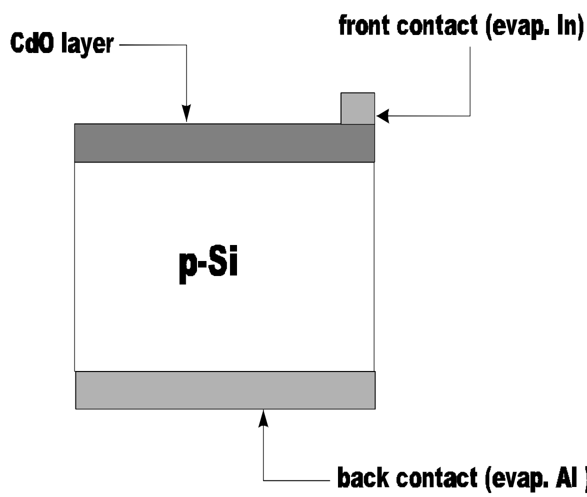

Fig. 1. CdO/p-Si structure diode.

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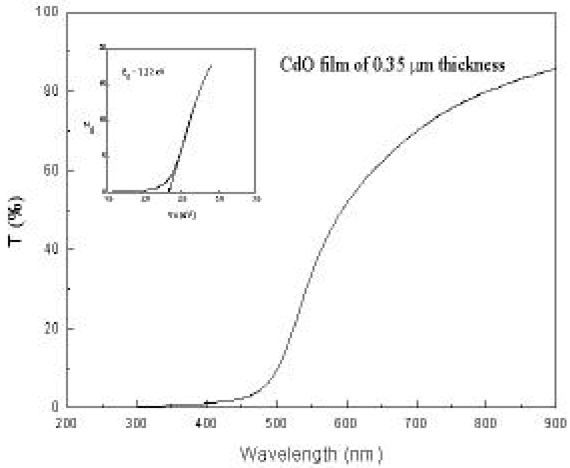

Fig. 2. Optical transmittance of CdO films used on the CdO/p-Si diodes.

Figure 3 shows the dark and under illuminated I-V plots measured at 300º K for a typical CdO/Si-p diode. Notice that the magnitude of the photocurrent under reverse bias exhibits a flat dependence when the voltage value is higher than 1.5 V. At this voltage the structure is suitable to be used as an efficient photodetector, taking into account the manufacturing low cost for this structure.

The spectral sensitivity curves were measurement under two different conditions: unbiased and reverse biased at 1.5 V. The polarized CdO/Si diode has a better spectral response than the non-polarized photodetector. This behavior is in agreement with that observed for the I-V illumination curve, where there is a threshold for the photogenerated current at this voltage. The good spectral

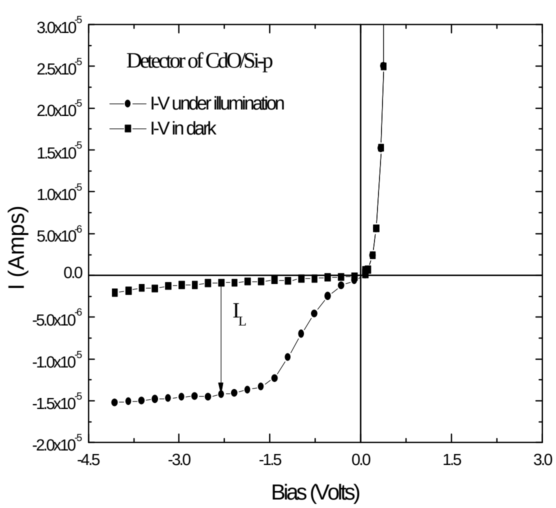

Fig. 3. Dark and illuminated I-V curves for a typical CdO/p-Si diode.

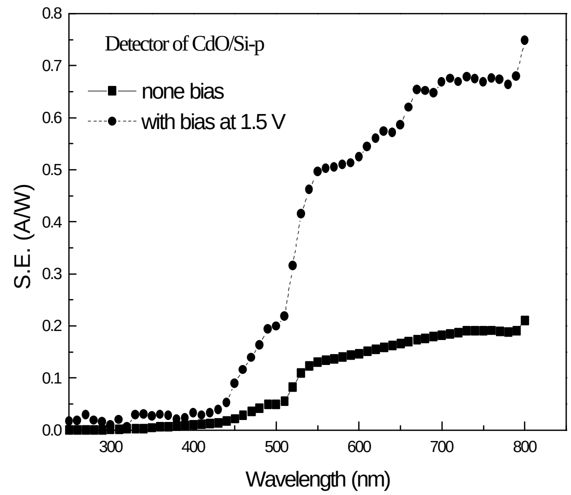

Fig. 4. Spectral sensitivity for CdO/p-Si diodes.

response observed in the near infrared is explained for the simplicity in the diode process manufacture, that does not contain high temperature steps, consequently the original minority carrier diffusion length is conserved. This is an advantage of the cheap process for obtaining a good photodetector.

4. Conclusions

We have obtained and characterized heterojunction photo-diodes made from (CBD) CdO on crystalline silicon which show very good spectral response at both the infra-red and blue regions of the visible wavelength. The simplicity for making these diodes makes them very attractive for their application as a possible substitute of conventional silicon photo-detectors. These diodes require a low reverse voltage (1.5 V) in order to achieve illumination response. We will make further work in order to understand the behavior and improve the characteristics of these simple and promising diodes.

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