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CURRENT -VOLTAGE CHARACTERISTICS OF CdO NANOSTRUCTURE ULTRAVIOLET PHOTOCONDUCTIVE DETECTOR

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Abstract: The Properties of photoconductive ultraviolet detector fabricated on CdO nanofilms were presented. The Cadmium Oxide (CdO) semiconducting transparent nanostructure film is deposited on glass and porous silicon substrates by spray pyrolysis. The structural and optical properties of the grown films are presented. The crystalline structure was studied by X-ray diffraction. The direct band gap of CdO nanofilm was found to be 3.4eV, comparing with that of the bulk CdO. The deposited CdO film was coated by nanosheet of polyamind polymer to improve the photoresponsivity of the detector.
Keywords: CdO nanostructure, Spray pyrolysis, XRD, Optical properties.

1. Introduction

Cadmium oxide (CdO) attracts a great attention due to its electrical and optical properties. CdO is an n-type semiconductor with a ranging direct band gap at approximately 2.2-2.7 eV [1-5]. CdO has many attractive properties such large energy bandgap, high transmission coefficient in visible spectral domain, remarkable luminescence characteristics etc.

Thin films of CdO have been prepared by employing various physical and chemical deposition techniques, such as evaporation, spray pyrolysis, solution growth, Langmuir-Boldgett deposition, sputtering, etc [6-10].

This materials have been widely studied for optoelectronic applications in transparent conducting oxides (TCO) [11], solar cells[12], photovoltaic device [13], photodiodes [14] as well as other types of applications like IR heat mirror, gas sensors [15], low-emissive windows, thin-film resistors, etc [16-17].

In the present study, synthesis and characterization of CdO nanostructure ultraviolet detector has been studied by depositing the CdO nanofilm on nanospikes silicon layer.

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2. Experimental Works

N-type Si wafer of 0.05 Ω.cm resistivity was used as a starting material in the photochemical etching. The samples of 2 x 2 cm^2 dimensions were cut from the wafer and rinsed with acetone and methanol to remove dirt. In order to remove the native oxide layer on the samples, they were etched in diluted (10 %) HF acid. After cleaning the samples they were immersed in HF acid of 50 % concentration in a Teflon beaker. The samples were mounted in the beaker on two Teflon tablets in such a way that the current required for the etching process could complete the circuit between the irradiated surface and the bottom surface of the Si sample.

Tungsten halogen lamp of 250 Watts integrated with diacnamic ellipsoidal mirror was used as the photon beam source. The photoetching irradiation time was chosen to be 10 minutes.

At the end of the photochemical etching process, the samples were rinsed with ethanol and stored in a glass containers filled with methanol to avoid the formation of oxide layer above the nanospikes film.

The CdO nanofilms were prepared by chemical spray pyrolysis technique. The films were deposited on porous silicon layer heated to (250ºC). A 0.1M Spray solution is prepared by dissolving cadmium acetate ($Cd(CH_3\ COO)_2.2H_2O$) of molecular weight equal to 266.527gm / mole in a mixture of methanol and deionized water (1:1). The above mixture solution was placed in the flask of the atomizer and spread by controllable pressurized nitrogen gas flow on the heated substrates. The spraying time was 4 seconds, which is controlled by adjustable solenoid valve. The heated substrate was left for 12 sec after each spraying run to give time for the deposited (CdO) layer to be dry. The optimum experimental conditions for obtaining homogeneous CdO thin film at (250 ºC) were determined by the spraying time, the drying time and the flashing gas pressure.

The thickness of the prepared films was measured by laser interferometer technique. The thickness of the films was found to be in the range between (800-1000μm). The micro mask of (0.4mm) electrode spacing was used to deposit the Aluminum (Al) electrical electrodes on the film surface.

The variation of photoresponsivity of CdO Photoconductive UV detector with the bias voltage was carried out under the illumination with UV diode of 2.5 mWatt power and of 385 nm wavelength.

3. Result and Discussion

3.1 Structural Characteristics

The X-ray diffraction (XRD) pattern of the CdO nanofilm deposited on nanospike layer of n–type silicon substrate is illustrated in Figure 1.

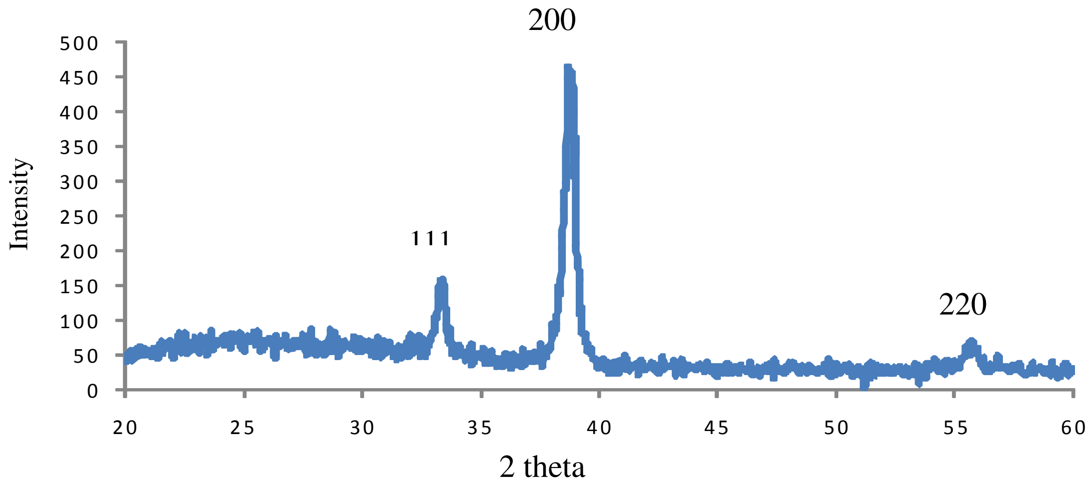

Figure 1. XRD of CdO nanofilm.

The figure shows the (111), (200), and (220) peaks occurred at 2Θ values of 33°, 38° and 55.2° respectively, with full width at half maximum (FWHM) of (200) peak of about 0.658°. The CdO nanofilm are strongly crystallized with a preferred (200) orientation, which has been observed by other authors [5,7,18]. Particle size was determined from the width of XRD peaks using Scherer's formula [19]:

$$D = \frac{K \lambda}{\beta \cos \theta}$$

Where D is the grain size, K is the shape factor, being equal to 0.9, λ is the wavelength of X-ray, β is the full-width at half maximum FWHM (degree), and θ is the diffraction angle in degree. Figure 1 shows the grain size of CdO sample (24.4nm) obtained from the FWHM of peak corresponding to $2\Theta=38.60^{o}$

3.2 Optical properties

The absorption spectrum of the CdO nanofilms deposited on glass substrate is shown in Fig 2.

The figure shows high absorption coefficient in the UV region, whereas it is transparent in the visible region. Assuming direct transition, the dependence of $(\alpha h\upsilon)^2$ on the photon energy hυ is plotted following Taue relation [20] and the graph is illustrated in Fig.3.

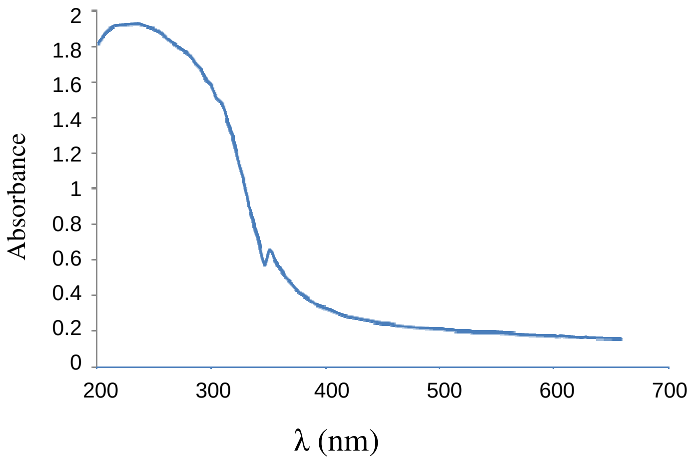

Figure 2. The absorpance spectrum of CdO nanofilm deposite on glass substrate.

The extrapolation of the linear part of the above plot to ($\alpha h\upsilon)^2 = 0$ give the energy gap value of the CdO nanofilm, which was found to be about 2.5eV, and 3.46 eV. The above two values may be related to the nanostructured CdO film and to bulk CdO material. This value is in a good agreement with the values presented by other workers [3-21].

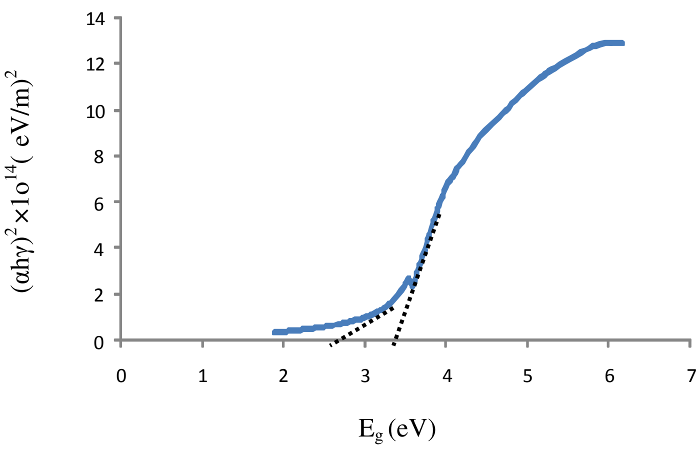

Figure3. $(\alpha h\gamma)^2$ versus E_g plot of CdO nanofilm

The photoluminescence spectrum of CdO nanofilm on glass substrate is plotted using SL 174 spectrofluorometer supplied by ELICO Company covering the 300–900 nm wavelength range. The room temperature photoluminescence spectrum of CdO film deposited on glass substrate excited by 300nm line is shown in figure 4.

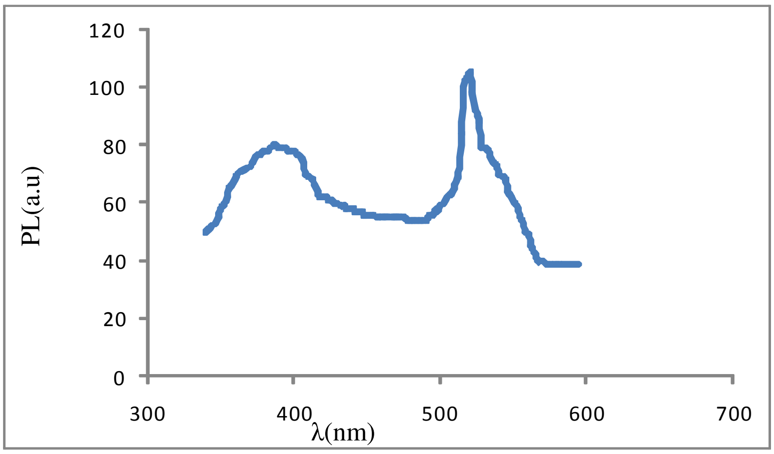

Figure 4: The Photoluminescence spectrum of CdO film on glass substrate

The spectrum shows two peaks: the first peak at 386 nm which can be referred to the strong direct band transition (or band to band transition). The second peak at 520nm is due to the exciton emission.

The energy band gap from photoluminescence spectrum of the CdO film is calculated by using the following equation

$$E_g = \frac{1240}{\lambda(nm)}$$

For the PL wavelength 386nm and 520nm the energy band gap found are to be (3.2 and 2.38eV). Similar peaks in spectrum of CdO have been reported by [22].

3.3 Electrical Properties

The variation of the photoconductive response of the fabricated photoconductive detector as a function of the bias voltage at dark and under illumination with UV source of 2.50 mw radiation power for etching time (10min) are illustrated in Fig .5.

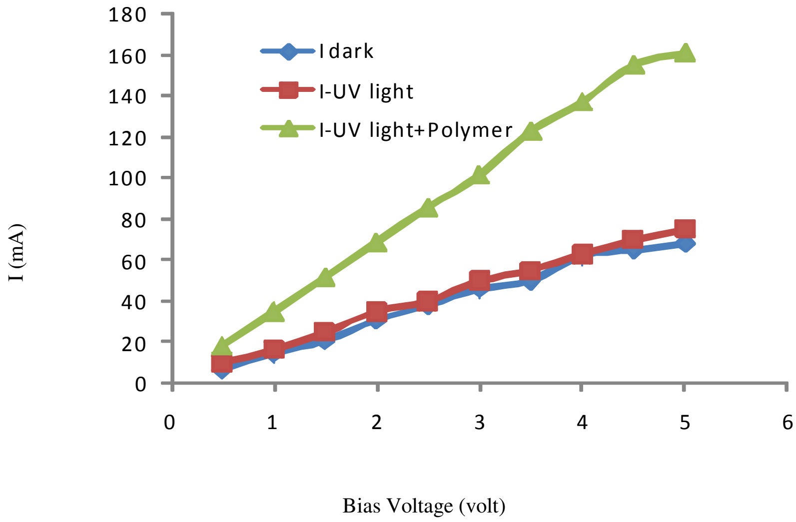

Figure.5. I-V characteristics of CdO nanofilm with and without polymer

It can be noticed from the figure that the dark current was about 68mA at 5 v bias whereas the photoconductive current was 161mA. This result reflects a good UV radiation sensitivity with photoconductive gain (G) of 2.36.

The functionalization of the CdO film surface by polyamide nylon improved the photoconductive gain as shown in Fig.5.

Conclusion

The CdO UV detectors prepared by chemical spray pyrolysis technique were fabricated on photochemical etched silicon substrates. The direct band gap of CdO nanofilm was found to be 2.5eV, and 3.46 eV. The above two values may be related to the nanostructured CdO film and to bulk CdO. The variation of the photoconductive response of the fabricated detector was 161mA and photoconductive gain (G) was 2.36.

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