Analysis of Linearity Response and Spectral Responsivity in CdS Photoconductive Detector

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Received on: 23/4/2008
Accepted on: 9/10/2008

Abstract

Thin films of cadmium sulfide have been deposited by chemical bath deposition. The effect of temperature and time deposition on spectral responsivity for CdS photoconductive investigation. The effect of temperature bath and time deposition where study. Linearity response of photoconductive detector were carry on analyzing the light current with incident power curves. The results show that high spectral non saturated responsivity was achieved, further the detector were manufacture with low cost.

Keywords : CdS thin films, photoconductive detector, CBD.

تحليل الاستجابة الخطية والاستجابة الطيفية لكاشف التوصيلية الضوئية CdS

الخلاصة

حضرت أغشية كبريتيد الكادميوم بطريقة الترسيب بالحمام الكيميائي. إذ درس تأثير درجة حرارة الحمام وزمن الترسيب على الاستجابة الطيفية لكاشف التوصيلية الضوئية CdS. وكذلك درس تـــأثير درجة حرارة الحمام وزمن الترسيب على الاستجابة الخطية لكاشف التوصيلية الضوئية بتحليل منحنيات التيار الضوئي مع القدرة الساقطة. حيث أبدى الكاشف المصنع بأقل كلفة استجابة عالية واستجابة خطية دون حصول أي استقرارية للتيار الضوئي مع القدرة الساقطة.

1 . Introduction

There is considerable interest in the deposition of compound semiconductors such as CdS by methods which involve low capital expense and are technically undemanding on the experimentalist. One process to meet these criteria is Chemical Bath Deposition (CBD). Such processing methods are particularly appropriate for the production of devices for which large areas and low cost are essential such as solar cells[1-3], detectors and other optical devices[4,5].

The films are smooth and uniform, adhere tightly to the substrates, are specularly reflecting and have reproducible properties, both structural and electrical. The quality and structure of the films depend on the different preparative parameters such as temperature of deposition, [pH],of the complex compound, deposition time, and concentrations of basic ingredients [5,6].

The linearity of photoelectric detectors response has been the subject of many interesting investigations[7].

The current intensity is known to vary with the intensity of the light. The relationship is often given as [7]

$$I_{PL}\; a\; I_L^{\,k} \qquad ....(1)$$

where k is the light intensity exponent value, I_{PL} is the photoconductive current and I_L is the light intensity. The many

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materials have been observed to follow relationship (1) [8]. For CdS photoconductive detector it is often claimed that they are linear over many decades. Very very little experimental evidence about the effect of temperature chemical bath deposition and time deposition on the linearity response can not be found in the literature.

In this paper, we report the analysis of linearity response. We also report on the effect of temperature bath and deposition time on spectral responsivity of CdS photoconductive detector.

2 . Experimental procedure

CdS films were grown using CBD technology on glass slides. This technology offers the deposition of a thin uniform film with a minimal thickness on the substrate surface. Substrate used for deposition CdS is borosilicate glass slides, which were first cleaned in distilled water in order to remove the impurities and residuls from their surfaces. Followed it rinsing in chromic acid (for one day), to introducing functional groups called nucleation and / or epitaxial centers, which formed the basis for the thin films growth. Then, repeated washing in deionized water, and finally put in ultrasonic wave with distilled water for 15 min then dried.

The reaction cell was a 100 ml beaker containing 0.1 M $CdSO_4$ aqueous solution, 0.2 M thiourea aqueous solution and 5.6 M NH_4OH in the volume ratio 1: 1: 1. the substrate were then suspended in the reaction cell. Reasonably good films of CdS were obtaind in 20 min at a constant temperature. The freshly grown films were thoroughly washed by water jet, dried and kept in a vacuum.

3 . Measurements

The spectral response of each photoconductive detector was measured using Jobin- Yovin monochrometer type R456. during the measurement the photoconductive detector were shielded so that the effect of back – ground signal and ambient variations were eliminated.

For linearity measureament a white light source type KL 150 B has been used. The optical power was measured by a reference detector and power meter. The light power was normalized to the area of the detector to obtain the optical power, as in the definition below [8]:

$$P_d = \frac{P_1}{A_1} A_d \qquad \text{……(2)}$$

where P_1 and P_d incident power on the standard and under test detectors, A_1 and A_d cross sectional areas of standard and under test detectors.

4 . Results and discussion

Figure (1) and (2) shows the variation in spectral responsivity for CdS films deposited in different temperature bath and different deposition time.

We can recognize three different regions on the curve. The first one at short wavelength (hu >Eg energy gap) implies a considerable increase in the responsivity and this increase relates to the high absorption coefficient. This leads to lower absorption depth and large surface recombination processes. In the second region (at 520 nm), we observe the highest value of the responsivity, because the region at 520 nm is related to CdS band gap. In the third region, (>520 nm), the incident light (hu < Eg) is absorbed within the material where the film has a high transmission and less absorption. Also, from figure we found at (> 650 nm) the dark current increase with bath temperature. Which it mean decrease resistivity with deposition temperature. All films exhibit a high responsivity about 0.2 (A/W) which falls sharply in the long wave length except the film deposited at 90 ^{o}C . The sharpness of the curve it means the film have high quality without defect.

For photoconductive detector, the illumination dependence of photocurrent for range of voltage biasing at different temperature is shown in Figure (3) and for different time deposition in figure (4). It is clear that, the light current increase linearly with incident power.

The current-light curves of detectors can be explained in terms of Rose postulate, in which the steady state Fermi levels (E_{+n}, E_{+p}) will be pulled apart under illumination. This pull apart process follow logically from the need to maintain charge neutrality. As they are pulled apart they embrace more ground states. More ground states mean that the carrier life time will be shorter. From the set of curves shown in figure (3,4), the current-light curve increases with exponent value .

The effect of bath temperature on light current and the effect of time deposition on light current is shown in figure (5), (6) respectively. The light current increase with increase in bath temperature and time deposition. As a result of increasing in film thickness with increase in bath temperature and time deposition.

The light current with biasing voltage at different bath temperature and at different time deposition is shown in figure (7), (8) respectively. It is clear that, the light current increase with increasing baising voltage at constant power intensity.

5. Conclusion

Chemical bath deposition is a simple and suitable method of obtaining adherent, specular, homogeneous and stoichiometric CdS yhin films. The CdS photoconductive have high spectral responsivity at 520 nm. And the linearity response of the photoconductive is greatly affected by the bath temperature and deposition time.

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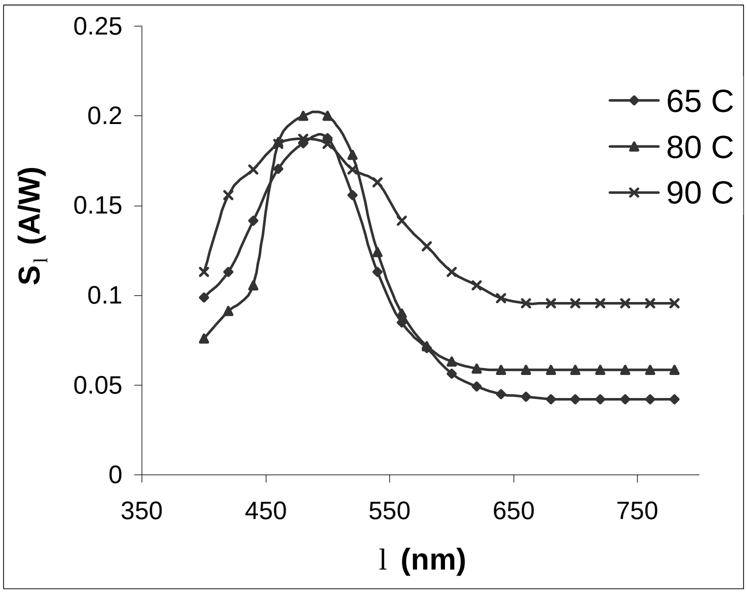


Figure (1) Spectral responsivity verse wavelength for CdS thin film for various bath temperature .

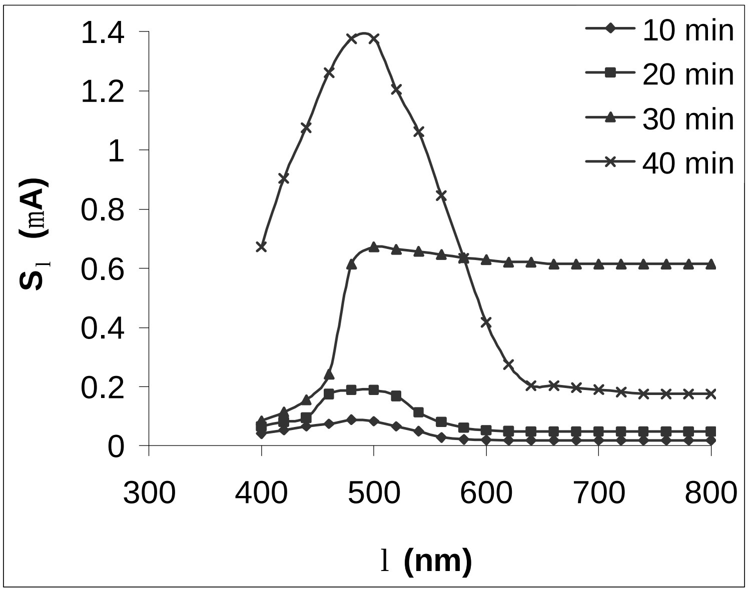
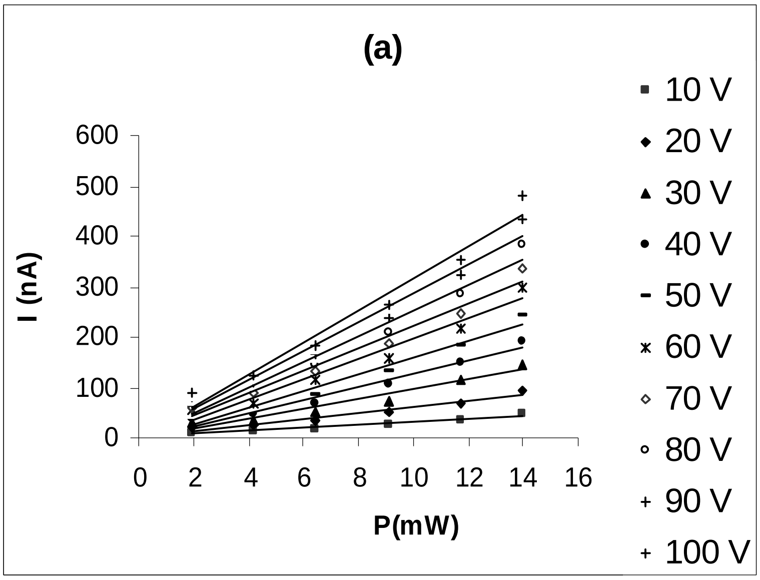


Figure (2) Spectral responsivity as a function of wavelength for CdS in different deposition time.



Figure(3a) I_{ph} verse power at different voltage values at bath temperature 80 ^{o}C.

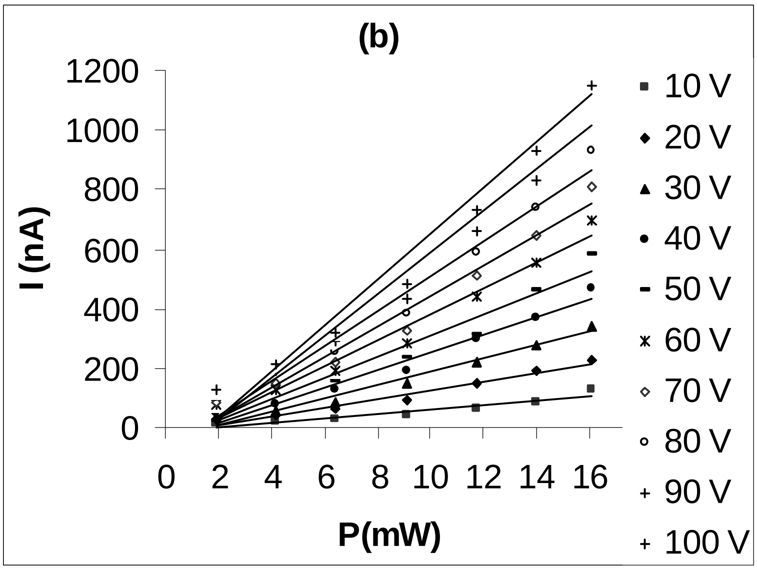


Figure (3b) the variation of I_{ph} with power for range of voltage at 90 ^{o}C.

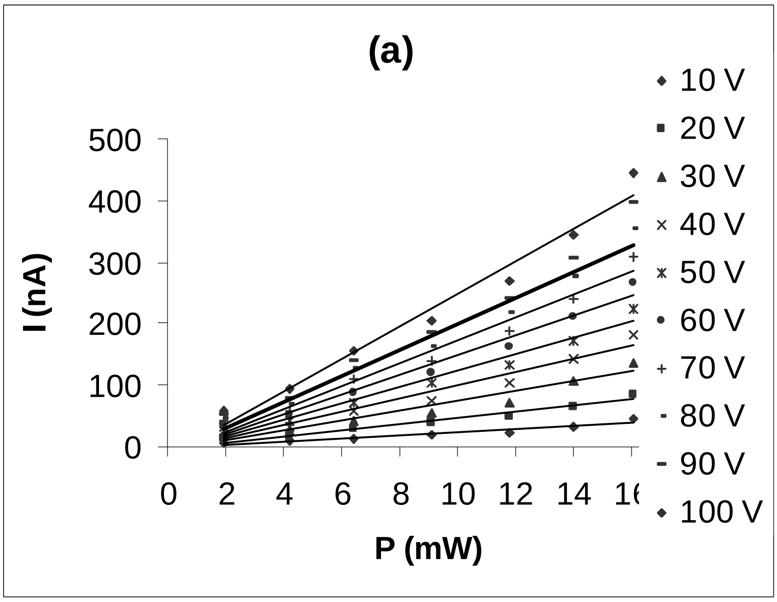


Figure (4a) The variation of I_{ph} with power for range of voltage for deposition time 10 min.

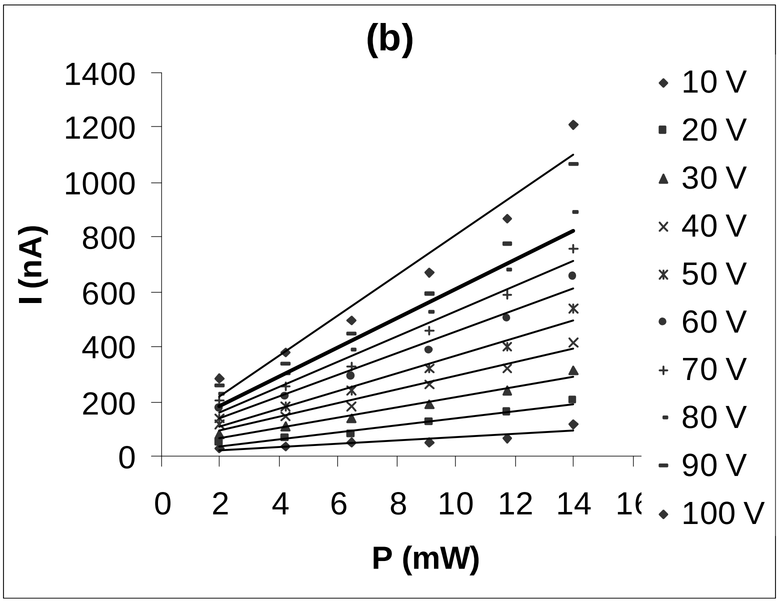


Figure (4b) the variation of I_{ph} with power for range of voltage for deposition time 30 min.

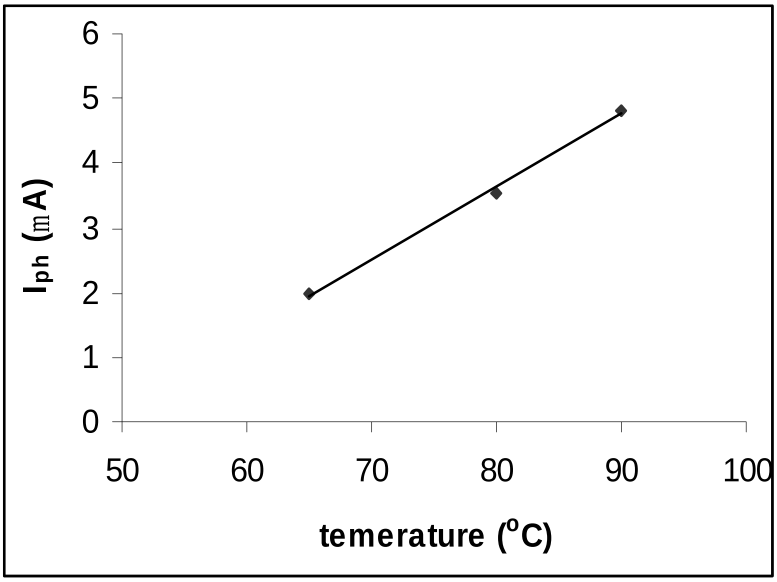


Figure (5) Relationship between light current and bath temperature.

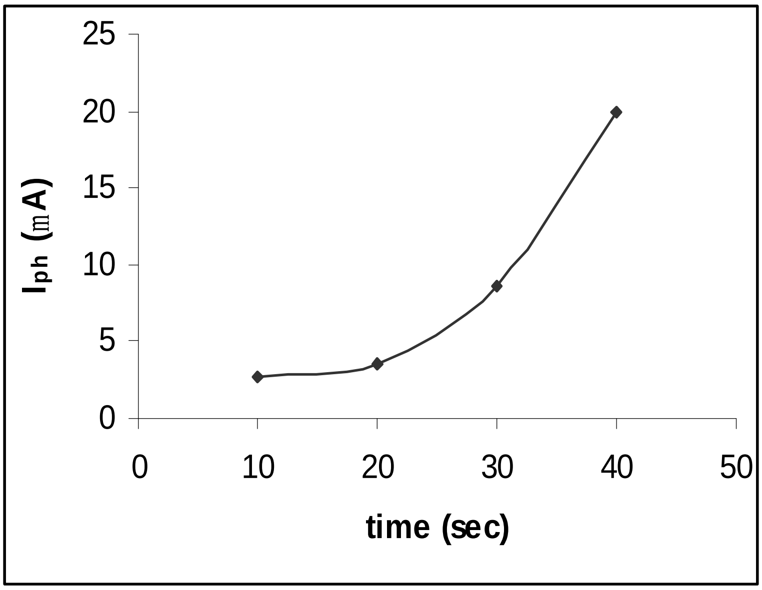


Figure (6) Relationship between light current and deposition time.

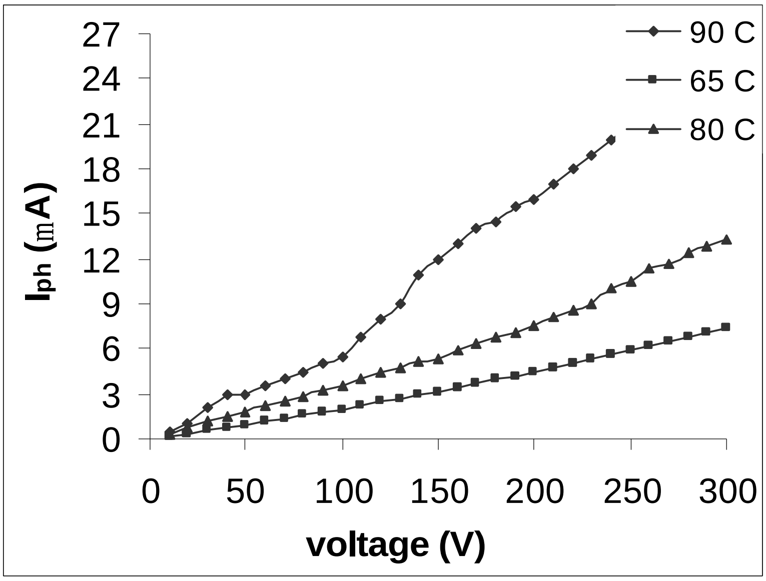


Figure (7) relationship between light current and applied voltage at different bath temperature.

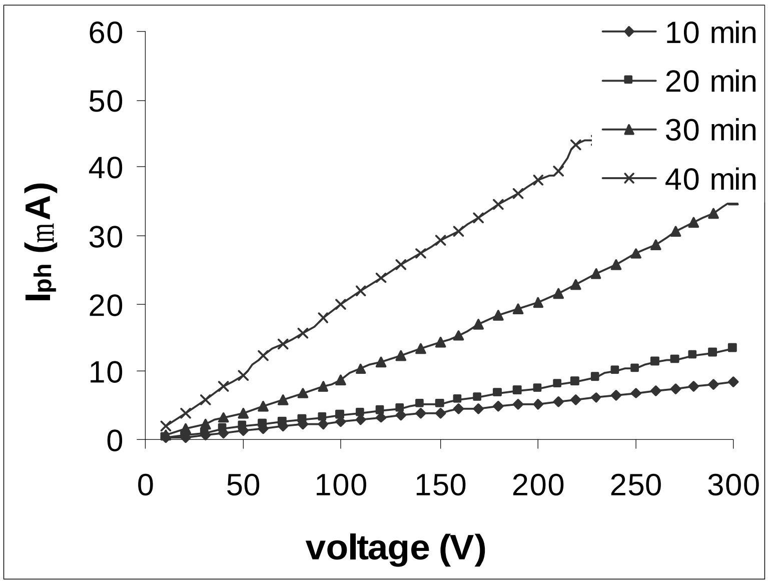


Figure (8) relationship between light current and applied voltage at different deposition time.