

# Photocurrent Measurements in Cadmium Sulphide Thin Films

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DOI: 10.29322/IJSRP.11.01.2021.p10977  
<http://dx.doi.org/10.29322/IJSRP.11.01.2021.p10977>

**Abstract-** Cadmium Sulphide (CdS) thin films prepared using sintering method have been investigated. The response of light illumination on the photocurrent is measured and analyzed. The effect of deposition time of powdered samples on the photoconduction process in the films is reported and discussed. Mention the abstract for the article. An abstract is a brief summary of a research article, thesis, review, conference proceeding or any in-depth analysis of a particular subject or discipline, and is often used to help the reader quickly ascertain the paper's purpose. When used, an abstract always appears at the beginning of a manuscript, acting as the point-of-entry for any given scientific paper or patent application.

**Index Terms-** Cadmium sulphide, chemical bath deposition, sintering, thin film, photoconduction

## I. INTRODUCTION

Chalcogenide semiconductor thin films are being intensively investigated for low-cost photovoltaic and optoelectronic applications [1-4]. Cadmium sulfide (CdS) is commonly used as n-type semiconducting layer for heterojunction thin films solar cells [2]. Multilayered CdS films can be employed in the manufacture of the optoelectronic devices [3,4]. The deposition of CdS film has been explored by various authors using techniques such as, thermal evaporation, sputtering, molecular beam epitaxy, spray pyrolysis, chemical bath deposition and sintering method [4-9].

Among the II-VI semiconductors, CdS polycrystalline thin films is a representative material with many applications such as large area electronic devices and solar cells[10]. It has a wide direct band gap (2.42 eV), so has been used as a window material together with several semiconductors such as CdTe, Cu<sub>2</sub>S and CuInSe<sub>2</sub> [3]. Also the interest in CdS thin films stems from its piezoelectric properties and potential laser applications [11]. Polycrystalline CdS films with different micro structures and properties of the CdS layer were fabricated by coating a number of CdS slurries, which consist of cadmium and sulphur powders, appropriate amount of ethylene glycol and various amount of CdCl<sub>2</sub>, on the sintered CdS films and by sintering the glass-CdS composites at various temperatures[12].

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

The sintering method is relatively inexpensive, simple and convenient for the large area of deposition of II-IV compounds. The present work is an effort to prepare the CdS films using sintering method and to study the effect of deposition time of powdered samples of CdS on the photoconduction process in these films. The present work is an effort to prepare the CdS films using sintering method and to study the effect of deposition time of powdered samples of CdS on the photoconduction process in these films.

## II. EXPERIMENTAL DETAILS

Commercially available glass substrates were used in the study. The substrates were first soaked in acetone for a minute and then dried in air. Thereafter, they were cleaned in isopropyl alcohol, washed with deionized water. Then the substrates were dried again in air before deposition of material [13].

The samples were prepared by chemical method using Cadmium Sulfide (CdS) powders. There were three CdS powders which were prepared at deposition times of 60 min, 90min and 120 min. [14]. CdS films were then prepared by the sintering technique [12]. For this, appropriate amount of Cadmium Chloride(CdCl<sub>2</sub>) was added as an adhesive and ethylene glycol as the binder. The weight of CdCl<sub>2</sub> was kept 10% of the weight of CdS powder. CdS and CdCl<sub>2</sub> were thoroughly mixed and then a few drops of ethylene glycol was added to form the paste. The paste was then painted on the glass substrates. After sintering, films were dried in air at room temperature for 24 hours. The prepared films were annealed between at 463K for 2 hours to make them homogeneous. After annealing, the colour of CdS thin film turns to dark yellow. The films are now well adhered to the glass plates and become uniform[12-14].

Light from an incandescent source was allowed to fall on the glass slide containing the film and a detector was mounted on the optical bench. The response of light illumination at various intensities was studied on the films. Photovoltage was measured using a digital multimeter (Aplab-Appa). The photocurrent versus intensity measurements were done using a nanoammeter (Omega).

## III. RESULTS AND DISCUSSION

### A. Variation of Photovoltage with Intensity

Figure1 shows the variation of photovoltage with light intensities at deposition times of 60 min., 90 min. and 120 min. Generally, it is observed that with the increase in intensity, there

is also an increase in photovoltage. The film deposited at 60min., show normal behavior. The photovoltage initially increases with intensity, then it becomes almost constant. For film deposited at 90 min, the photovoltage increase is smaller compared to films deposited for 60min. In case of film deposited at 120 min, the photovoltage has value between films deposited for 60min and 90min., but overall response is similar to other films. The constant values obtained for photovoltage can be assigned to site saturation and depends on the growth of film[15].

The response of voltages on different deposition times for various intensities are approximately similar. It is observed that for maximum intensity, photovoltage for film deposited for 60 min. increases but photovoltage corresponding to deposition time of 90 min. first decrease and then increase. Similarly, for other intensities, photovoltage starts increasing for films deposited for 60 min, then it decreases for films deposited for 90 min, and increases for films deposited for 120 min.. This can be due to optimum conditions reached for film growth for 90min duration and hence less number of carriers are available for excitation and conduction[14].

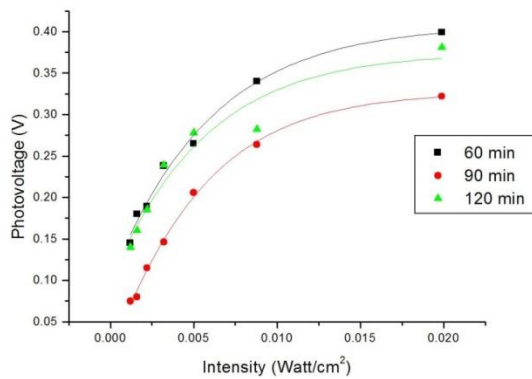


Figure 1 Variation of photovoltage with intensities for various deposition times

### B. Variation of Photocurrent with Deposition Time

The variation of photocurrent measurements are displayed in figure 2-4. In all the cases, the variation of photocurrent is found to increase with time and then saturates to a almost constant value. Initially, high value of the photocurrent is due to the absorption of photon by the films, which excites the electrons from the valance band to conduction band. This creates pairs of free holes in valance band and free electrons in conduction band. Most of the electrons are from the surface of the CdS film which moves from valance band to conduction band, thereby it increasing the process of pair generation initially, which in turn increase the carrier concentration and hence the number of excited states.

When light is switched off, the current starts to fall rapidly and reached a certain minimum value which is approximately same for all the films deposited at different times. The photocurrent decrease with time and after some time, the photocurrent is almost constant. This occurs as the carrier concentration decreases with time. Also the process of recombination takes place with respect to time which decrease the value of current. A

state is obtained where the process of generation of charge carrier and recombination reaches an equilibrium. This results in a constant photocurrent with respect to time. Here, surface recombination is very high and it leads to a lower carrier concentration at the surface which decreases the value of photo current.

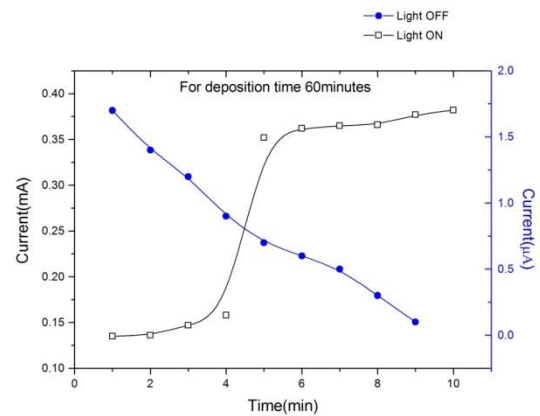


Figure 2 Variation of photocurrent with time for film deposited for 60 min.

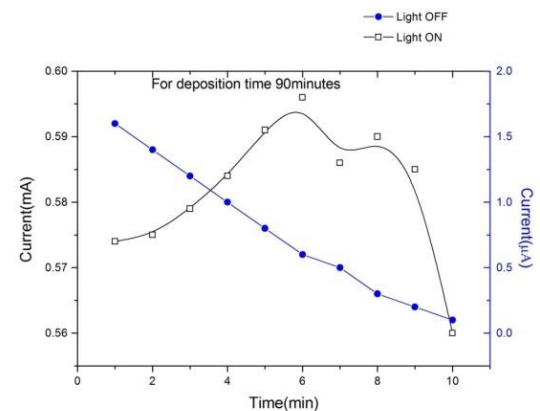


Figure 3.4 Variation of photocurrent with time for film deposited for 90 min.

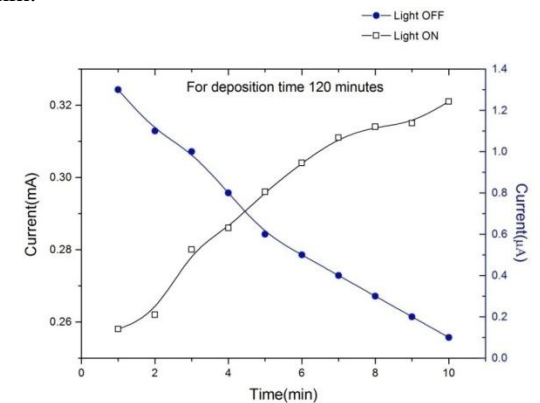


Figure 4 Variation of photocurrent with time for film deposited for 120 min.

In CdS films, the Fermi level is located in the upper region of the forbiddenband and so chemical bath deposited CdS films are n-

type. This is consistent with the common observed feature that CdS thin films are natively n-type [16]. It is worth noting that defects such as sulfur vacancy VS or Cd interstitial ICdS are donor defects in CdS thin films. Moreover, CdS thin films are generally S defective material, therefore, CdS thin films are natively n-type semiconductor. Due to sulfur volatility, S vacancies concentration is enhanced with increasing the deposition temperature and deposition time [17]. This induces an increase in the conductivity and the motion of Fermi level towards the bottom of conduction band edge. It is reported that an effective way to obtain CdS films with low resistivity and high optical transmittance can be achieved by the creation of excess Cd through various heat treatments and/or incorporation of foreign trivalent atoms as donors [18].

#### IV. CONCLUSION

The CdS films have been prepared using the sintering technique from powdered samples prepared using chemical bath deposition. The films are found to be photoconductive and photosensitive in nature. The photovoltage values measured were found to increase with increase in intensity. At each of the measured intensities, with increase in deposition time, the photovoltage increase for film prepared at 60 and 120 min., but comparatively photovoltage decreases for film prepared at 90min. In the ON state, the photocurrent first increase and then it becomes constant. In the OFF state, current falls abruptly and attains a definite value. This indicates that the prepared films are photo sensitive and can be used as photosensor.

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