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Variation of Photo-Transmission Current with Color Filters of Cds Thin Films Using Sintering Method

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Abstract

Cadmium Sulphide (CdS) films having 3 different deposition times of 60 minutes, 90 minutes and 120 minutes were prepared using sintering method. CdS films were then annealed to make them homogeneous. The films were mounted in front of 100 Watt light bulb. The colored filters (red, blue and yellow) were set near the prepared CdS films. A nanometer was used for measuring photo-transmission current through photodetector. The optical transmission spectra of CdS thin films as a function of wavelength for the films prepared having different deposition times were obtained. When light is on, the photo-transmission current is almost constant and when light is off, it decreases slowly with time. The responses are shifted according to the wavelength. The color having the maximum transmission current will show better response. For film having deposition time 60 minutes, the response of red colored filter is better than yellow and blue colored filters For film having deposition time 90 minutes, the response of yellow color filter is better. For film having deposition time 120 minutes, the response of blue colored filter is better. In this case, when the light is off, yellow filter gave very fast response.

Keywords: Optical Transmission Spectra; Photo-Transmission Current; Sintering Method; Annealing.

Introduction

Chalcogenide semiconductor thin films are being intensively investigated for low cost photovoltaic and optoelectronic applications. In the development of photovoltaic cell devices, one of the most important issues is the cost of production process including the cost of materials and the cost of technological process. The device for production of clean energy need clean technology. Among various technologies available now a days, sintering is believed to be one of the cleanest ways in achieving this goal. However, efforts are still needed to make sintering cost competitive over other established technologies for energy production (Sattarian et al, 2016). It has opened the possibilities to develop low cost solar cells. Sintering is a simple, highly efficient and inexpensive technique to obtain homogeneous, hard, adherent, transparent and stoichiometric CdS thin films. It has been reported that CdS may have either cubic or hexagonal structure depending on the synthesis conditions (Abdullah et al, 2012). X-ray diffraction results showed that the film structure was a mixture of two phases-hexagonal and cubic and it was very important to control deposition time to the film's crystal phase (xing et al, 2011).The study revealed that CdS films have tensile strain along the hexagonal planes (Rakshani et al,2000). Cadmium sulphide (Cds) is a very useful optoelectronic (Iyechika et al 1988; Bogdanov and Lyssenko, 1988; Obi et al, 2017), Piezoelectronic (Stefko V V,1991; Kerk and Kelly,1964) and semiconducting material. Owing to their suitable band gaps and high absorption coefficients , Cd-based compounds such as CdTe and CdS are most promising photovoltaic material available for low cost high efficiency solar cells (Safa et al 2017). The energy dispersive analysis of X-ray showed the CdS film to be stoichiometric (Ankurkumar et al 2018). The phase of CdS films was determined to be hexagonal (W G C Kumarage et al 2017).

There has been a rapid development in the field of 11-V1 semiconductors for their use in solar cells. Belonging to this group Cadmium sulphide is the most widely used material because it has intermediate energy gap,stability and low cost (Lee and Im 1980 ;

Nakayama et al 1980). It has a wide direct band gap and hence it has been used as a window material together with several semi conductors.

Synthesis of 3 D complex structures of CdS thin films and studies on their properties are significant and need to be developed, because the structures with complexities exhibit more novel properties, which would be useful for the existing as well as novel application devices (Sarveswaran et al 2016). The photovoltage of CdS thin films prepared by sintering method was measured for different intensities and it was found that it increases with increase in intensity (Raka Yadav, 2018).

This paper is an effort to prepare the CdS films using sintering method and to study the variation of photo-transmission current with time for films prepared for different deposition times with color filters (different wavelengths).

Objective of the Study

To study the variation of photo-transmission current with time for films prepared for different deposition times of CdS thin films using sintering method with color filters of different wavelengths.

Experimental Procedure

Commercially available glass substrate was first soaked in acetone for a minute and then dried in air. Thereafter, they were cleaned in isopropyl alcohol and washed with DI water. Then the substrates were dried in air before sintering. Then samples were made with the help of three CdS powders which were prepared for deposition times of duration 60 min, 90min and 120 min.

Cadmium Sulfide films were prepared by the sintering technique. For this, appropriate amount of Cadmium Sulfide, Cadmium Chloride ($CdCl_2$) was added as an adhesive and ethylene glycol as the binder. The weight of $CdCl_2$ was only 10% of the weight of CdS powder. The concentration of CdS and $CdCl_2$ with deposition time 60min, 90min and 120min are shown in table below

CdS weight (mg)	$CdCl_2$ weight (mg)
0.417	0.0417
0.152	0.0152
0.151	0.0151

CdS and $CdCl_2$ were thoroughly mixed and then a few drops of ethylene glycol were added to form the paste. The paste thus prepared was painted by paint brush on the half of glass substrates and the films were prepared.

After sintering, films were dried in air at room temperature for one day. The glass substrates were annealed between 85-90^oC for 2 hours on the hot plate to make them homogeneous. After annealing the color of CdS thin film turned to slightly dark yellow. The films now became uniform and well adhered to the glass plates.

Light from 100 watt bulb is allowed to fall on the glass slide containing the film. A setup was made in which films were mounted in front of light bulb and the filters were set near the prepared CdS films. A nanometer was used for the measurement of photo-transmission current through photodetector.

Experimental Results and Discussion

Variation of Photo-Transmission Current with Time for Films Prepared for Different Deposition Times With Colour Filters (Wavelength)

To study the response of color filters on the CdS films, a set up was made to estimate the photo-transmission current of light through the various color filters on the prepared films. In this set up films were mounted in front of light bulb and the filters were set near the prepared CdS films. A nanometer is used for the measurement of photo-transmission current through photodetector. The optical transmission spectra of CdS thin films as a function of wavelength for the films prepared for different deposition times were obtained. The maximum transmission obtained was in the case of least thickness (low deposition time), while the highest thickness (high deposition time) leads to minimum transmission.

Table 1(A) For Deposition Time 60min with RED Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	1.012	12.3
2	1.007	12.2
3	1.005	12
4	1.003	11.8
5	1.001	11.7

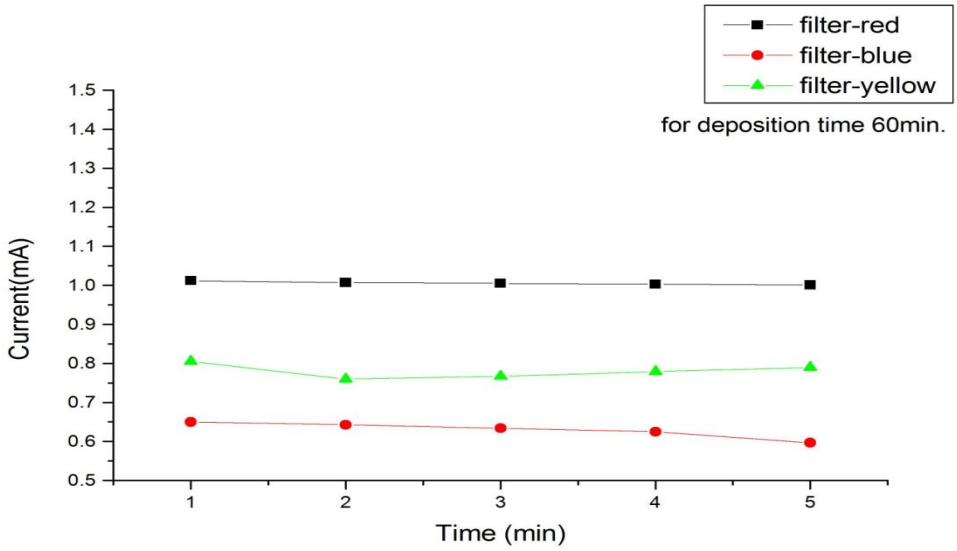
Table 1(B) For Deposition Time 60min with BLUE Colour Filter-

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	0.65	12.6
2	0.643	12.4
3	0.634	12.2
4	0.625	11.9
5	0.597	11.8

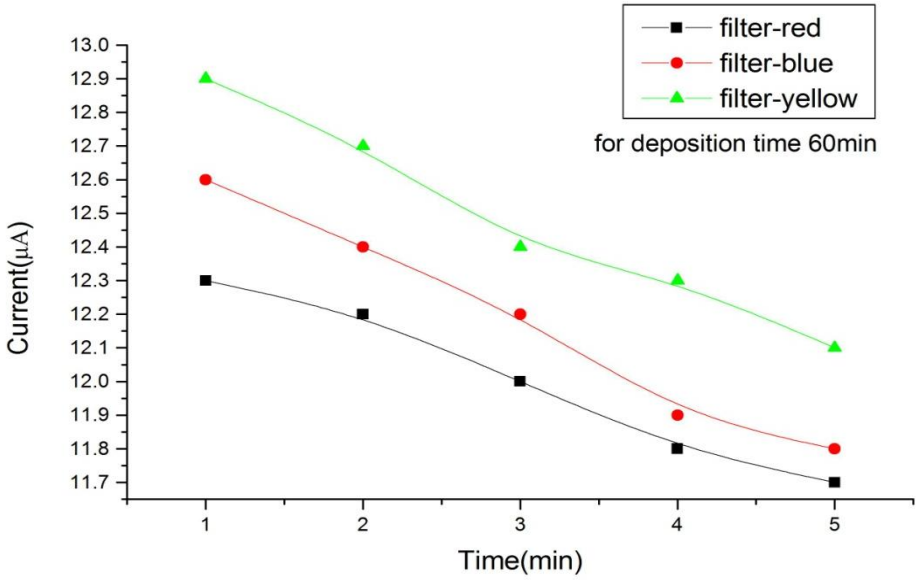
Table 1(C) For Deposition Time 60min with YELLOW Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	0.805	12.9
2	0.76	12.7
3	0.767	12.4
4	0.779	12.3
5	0.79	12.1

Plot between Photo-Transmission Current And Time For Deposition Time 60min With Filters



For film having deposition time 60min, the response of all the three filters is almost same. Photo-transmission current is almost constant for red colour fiter, it slowly increases for yellow from 0.76mA to 0.79mA and the response is minimum for blue colour filter decreasing slowly from 0.65mA to 0.597mA. Hence the responses are flat and they are shifted according to their wavelength. As shown in graph for film having deposition time 60min, the response of red colour filter is better than yellow and blue colour filter.



When light is off , the photo-transmission current slowly decreases with time for every filter. It means the behavior is almost same for every filter and it is shifted for colour filters. When light is off, in the response of yellow colour filter, the photo-transmission current decreases from 12.9μA to 12.1μA. The value of current for red and blue filters are from 12.3μA to 11.7μA and 12.6μA to 11.8μA respectively.

Table 2 (A) For Deposition Time 90min with RED Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	0.822	14.2
2	0.821	13.9
3	0.825	13.7
4	0.828	13.5
5	0.831	13.3

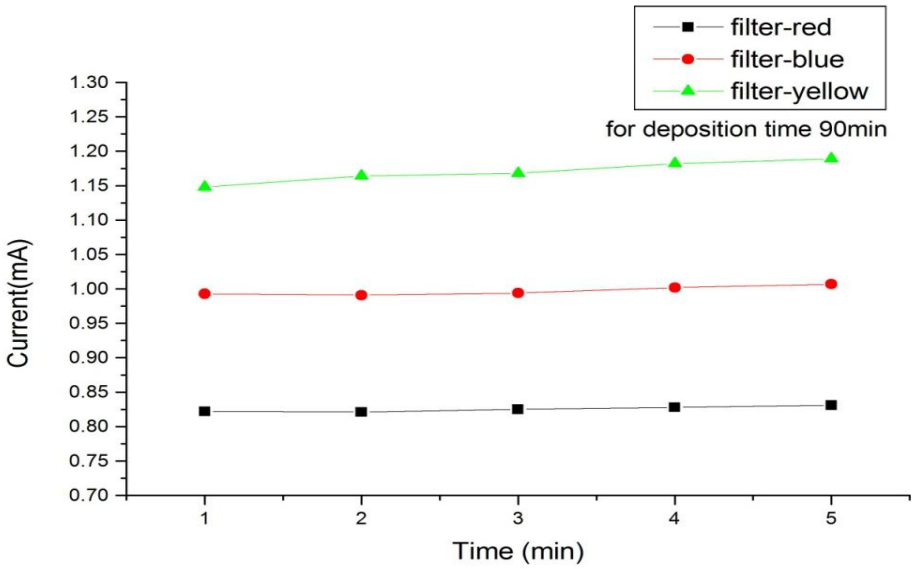
Table 2 (B) For Deposition Time 90min with BLUE Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	0.993	14.3
2	0.991	14.1
3	0.994	13.9
4	1.002	13.7
5	1.007	13.5

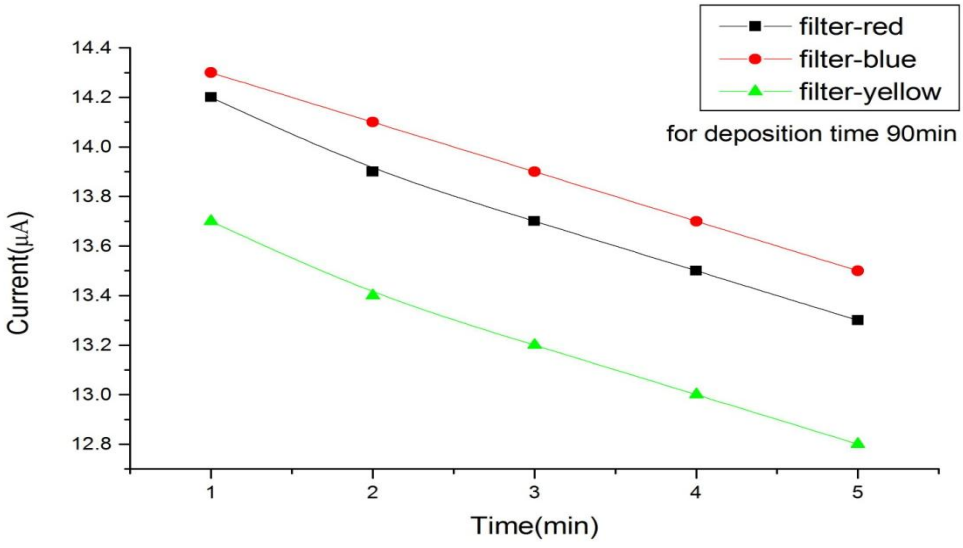
Table 2 (C) For Deposition Time 90min with YELLOW Colour Filter

Time (min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(μA) (when light is OFF)
1	1.148	13.7
2	1.164	13.4
3	1.168	13.2
4	1.182	13
5	1.189	12.8

Plot For Deposition Time 90 Min Between Photo-Transmission Current And Time With Filters



For film deposited for 90 min, the response of all filters are flat. The response is better for yellow colour filter because it has maximum photo-transmission current and the value of this is from 1.148mA to 1.189mA. Generally the response of yellow filter is good in transmission. Hence, the sensitivity of yellow colour is maximum. The human eye can sense the different colour with maximum sensitivity at approximately 550nm, which lies between green and yellow colours. But this maximum sensitivity is not fixed and varies from person to person. And plot of red and blue filter are almost same and flat. The values of photo-transmission current for red and blue filters are from 0.821mA to 0.831mA and 0.991mA to 1.007mA respectively .



When light is off for this film the photo-transmission current decreases slowly with time for every filter. The value for blue coloured filter decreases from 14.3µA to 13.5µA and for red and yellow filters the values decrease from 14.2µA to 13.5µA and 13.7µA to 12.8µA respectively.

Table 3 (A) For Deposition Time 120min With RED Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(µA) (when light is OFF)
1	0.672	13.5
2	0.668	13.3
3	0.618	13.7
4	0.622	12.9
5	0.632	12.8

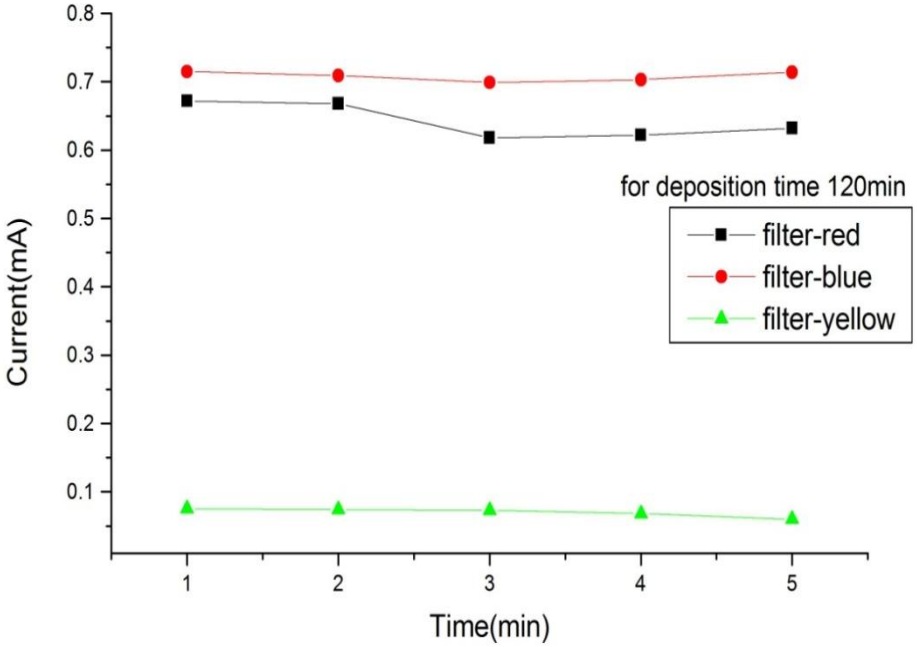
Table 3 (B) For Deposition Time 120min With BLUE Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(µA) (when light is OFF)
1	0.715	13.2
2	0.709	13
3	0.699	12.8
4	0.703	12.6
5	0.714	12.5

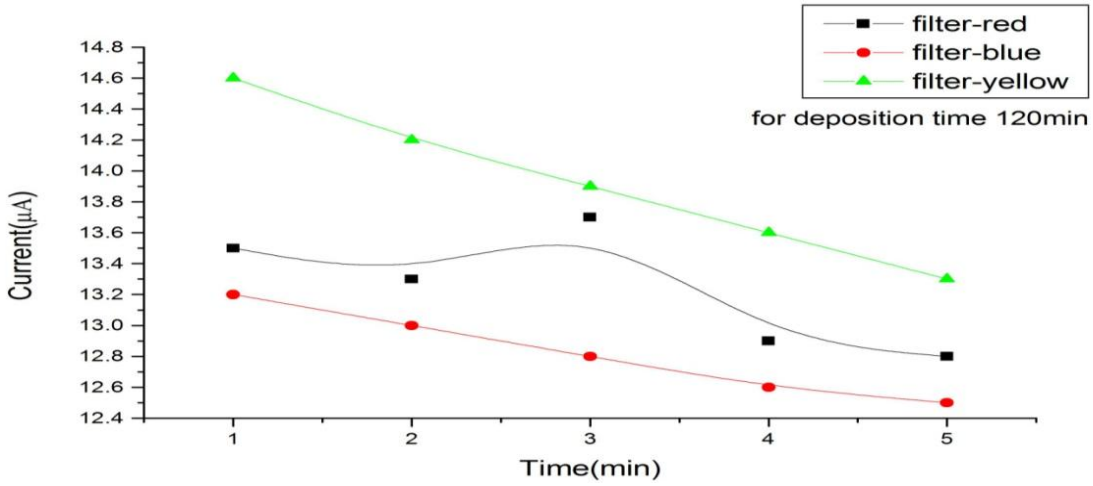
Table 3(C) For Deposition Time 120min With YELLOW Colour Filter

Time(min)	Photo-transmission Current(mA) (when light is ON)	Photo-transmission Current(µA) (when light is OFF)
1	0.075	14.6
2	0.074	14.2
3	0.073	13.9
4	0.068	13.6
5	0.06	13.3

Plot between photo-transmission current with time for deposition time 120min with filters-



For the film prepared having deposition time 120 min, the response is better for blue colour filter. It crosses the maximum photo-transmission current. The value of current is from 0.699mA to 0.714mA. The photo-transmission current for red and yellow filters are from 0.672mA to 0.632mA and 0.075mA to 0.06mA respectively.



When light is off, the photo-transmission current falls down with time for every filter. The yellow filter gave its response very fast to this film. The value of current for yellow filter is from 14.6μA to 13.3μA. The values for red and blue filters decrease from 13.5μA to 12.8μA and 13.2μA to 12.5μA respectively.

Conclusions

In this work, sintering technique has been used for the preparation of CdS films. The prepared films were found to be photoconductive in nature and hence the material can be used for fabrication of semiconducting devices such as solar cells, photodetectors etc. The CdS films are yellow in colour and increase of deposition time may darken its colour.

The effect on the characteristics of CdS film with filter is different for each film. For film with deposition time 60 min, the response of red colour filter is better but for film with deposition time 90 min, the response of yellow colour is better. For film with deposition time 120 min, the response for blue colour is better. This can be related to different particle size of CdS materials in the samples taken for experiment.

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