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Structural and optical properties of CdS thin films obtained by spray pyrolysis

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ABSTRACT

Cadmium Sulphide (CdS) thin films were prepared by Chemical Spray Pyrolysis technique. Cleaned glass substrates were used. The Substrate was maintained 300^0c the films were Characterized by X-ray diffraction (XRD). The structure of these films studied by X-ray diffraction were polycrystalline hexagonal phase. Direct band gap values of 2.42 eV -2.36 eV were obtained from optical absorption measurements. The refractive index is reported on depending on the Substrate temperature, and were obtained from transmission spectra. The thickness of these films were determined by Weighing method and in the range of t = 2289 µm, t = 2989 µm and t = 4379 µm

Keywords : Structural and optical properties, spray pyrolysis.

INTRODUCTION

CdS thin films are regarded as one of the most promising materials for heterojunction thin films solar cells. Wide band gap CdS (Eg=2.4eV) has been used as the window material together with several semiconductors such as CdTe[1], Cu_2S[2], InP[3] and $CuInSe_2$[4] with 14-16% efficiency [5]. However due to high cost of such a material, studies were developed towords polycrystalline compound semiconductors and particularly thin polycrystalline films. The deposition of CdS films has been explored by different techniques. Thermal evaporation [6,7], Chemical bath deposition (CBD) [8], molecular beam epitoxy [9], and spray pyrolysis [10]

Several methods are reported for the preparation of $CuInS_2$ thin film such as electrodeposition,[11], Pulse lasor deposition[12], Physical vapor deposition[13], vaccum evaporation[14], close space sublimation[15], But all these methods have sophisticated requirement in other to precise temperature control, high pressure etc. Besides all above methods Spray pyrolysis techniques simple, convenient and cheaper.

MATERIALS AND METHODS

All reagents used are of analytical purity, $CdCl_2$ and thiourea is used as precursor for Cd and S respectively and which are purchased from LOBA Chemical, Nagpur.

Experimental :
The spray pyrolysis technique is a simple technology in which an ionic solution-containing the constitutent elements of a compound in the form of soluble salts-is sprayed onto over heated substrates using a stream of clean, dry air. The CdS thin films were prepared by spraying an aqueous Solution of cadmium chloride ($CdCl_2$) and thiourea [$(NH2)_2$ CS] on glass substrate kept at 300^0c. The automization of the chemical solution into a spray of fine droplets is effected by the spray nozzle, with the help of compressed air as carrier gas. The spray rate was about $15cm^3$/min. through the nozzle ensures a uniform films thickness. The substrates are glass substrate

The temperature of substrate was controlled by an iron constantan thermocouple. After deposition, the films were allowed to cool at room temperature. Spray pyrolysis through is expensive, requires the use of sophisticated materials and overall, it is not impressive, now good quality semiconductors which allows fabrication of solar cells with satisfactory efficiency. Cadmium sulphide thin films have received considerable attention due to their applications in thin film solar cells [16], electrochemical cells [17] and semiconductor metal schottky barrier cells [18].

CdS is a technologically useful material, as many devices based on CdS, including sensors have come up in the recent years. The thin film cadmium sulphide soar cells has for several years been considered to be a promising alternative to the more widely used silicon devices.

One of the most promising techniques for producing large areas of inexpensive CdS film for terrestrial photovoltaic application is spray pyrolysis and here we followed this method to synthesize the CdS film. The structural properties of this films are carried out by X-ray diffiraction and optical study in the UV-VIS region by spectrophotometer.

The aim of this work is to produce CdS thin films by means of the spray pyrolysis technique and to investigate their structural optical properties. Optical properties were obtained by transmission spectra. (TS).

RESULTS AND DISCUSSION

Structural Properties :
Films are prepared at 300^0c as substrate temperature and the concentration of the precursor aqueous solution as .01 M. Golden yellow coloured film is obtained and the X-ray diffraction (XRD) patterns were recorded first for the spray deposition film. As an example, X-ray pattern for the film prepared at 300^0 c as the substrate temperature, .01M as Cadmium chloride and .01M thiourea in the volume ratio of 1:1. From the XRD, the films are found to be in the single phase of CdS and the identification of the peaks indicate that the films are polycrystalline.

The average grain size was calculated from the scherrer formula, which involve the width of the X-ray diffraction line [19]

$$G = \frac{0.9\lambda}{D\cos\theta} \text{------------------ (1)}$$

Where θ is the diffraction angle, λ is the wavelength of the X-ray source and D is measured in radians as full-width at half maximum of the diffraction line. The grain size of CdS thin films were found to be about 8.3655 nm and 57.155 nm

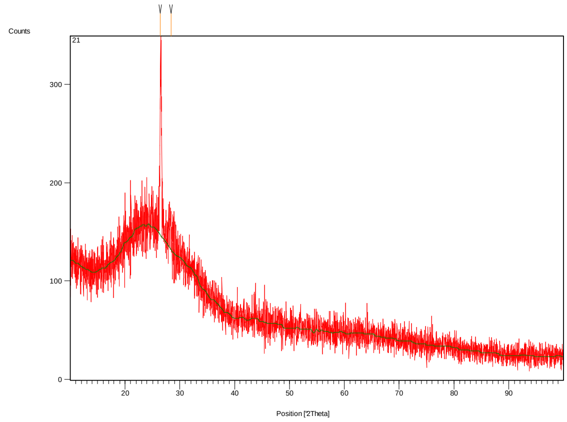

Fig. 1 X-ray diffraction pattern of sprayed CdS film at substrate temperature, 300^OC

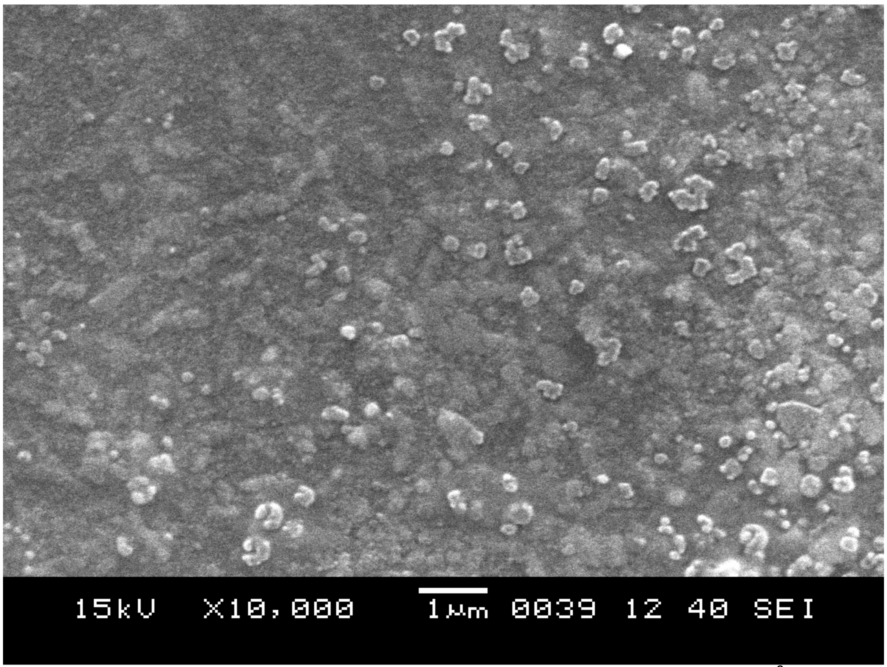

Fig. 2 Scanning Electron microscopy as deposited CdS on glass substrate at 300^0C sprayed CdS film

Optical Properties :

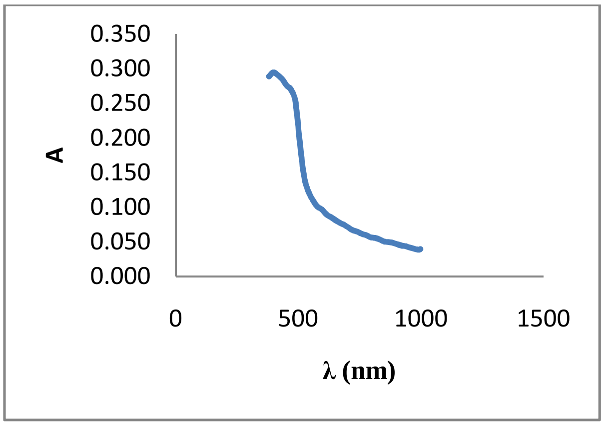

Fig : 3a The absorption spectra of CdS thin Film as a function to the wavelength t=2289μm

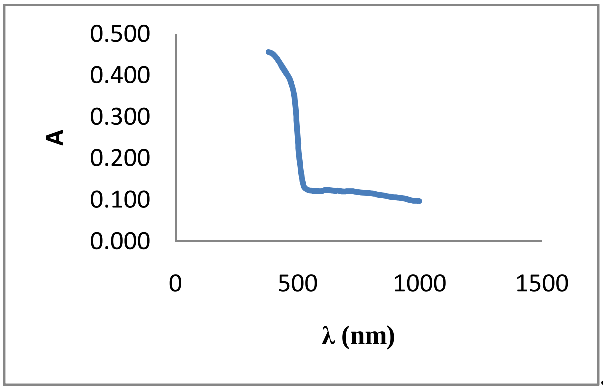

Fig : 3b The absorption spectra of CdS thin Film as a function to the wavelength t=2989μm

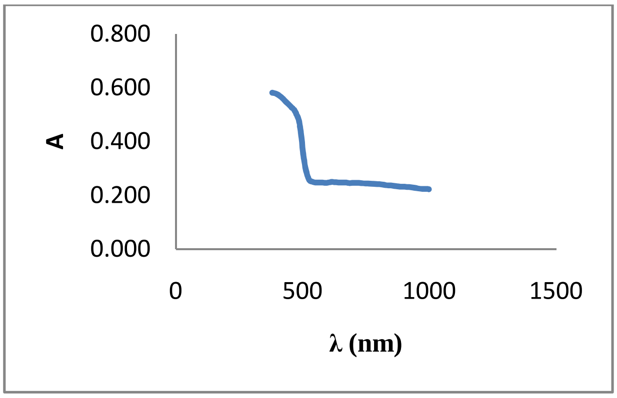

Fig : 3c The absorption spectra of CdS thin Film as a function to the wavelength t=4379µm

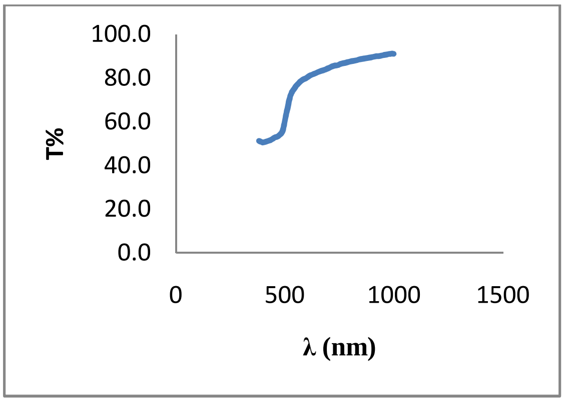

Fig :4a The Transmission spectra of CdS thin Film as a function to the wavelength t=2289µm

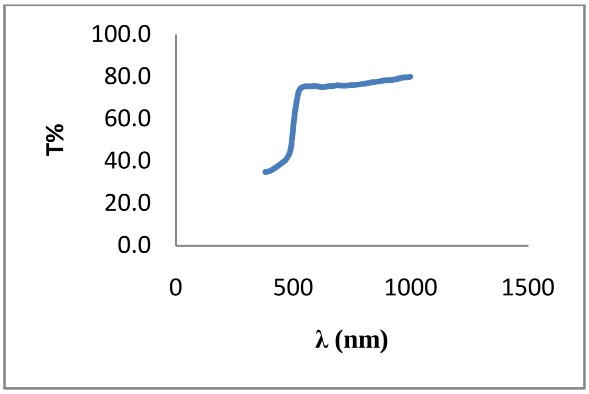

Fig. 4b The Transmission spectra of CdS thin Film as a function to the wavelength t=2989µm

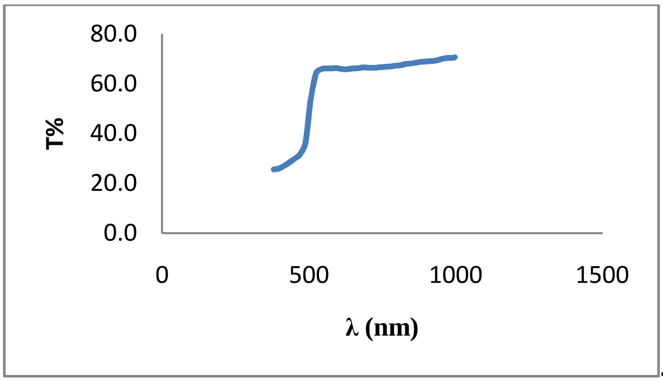

Fig. 4c The Transmission spectra of CdS thin Film as a function to the wavelength t=4379µm

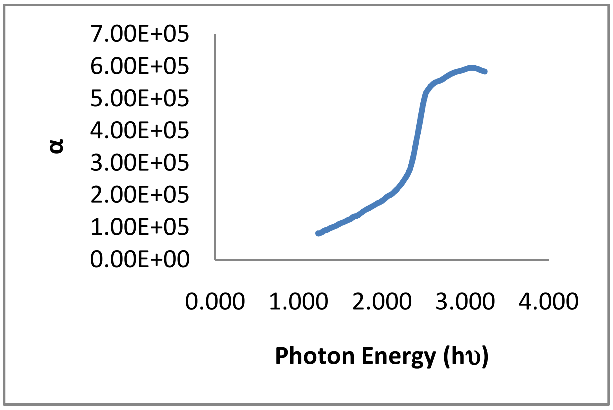

Fig. 5a The absorption Coefficient of CdS thin Film as a function to the wavelength t=2289µm

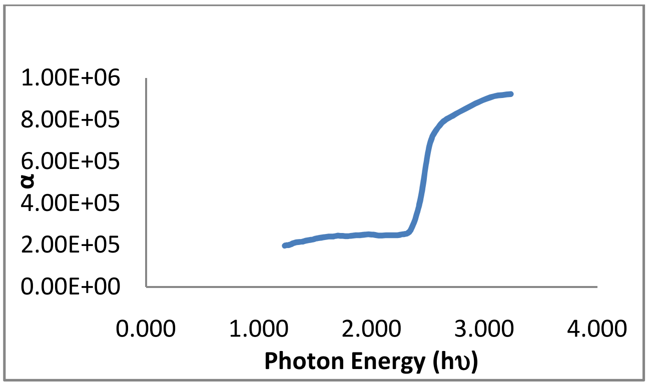

Fig. 5b The absorption Coefficient of CdS thin Film as a function to the wavelength t=2989µm

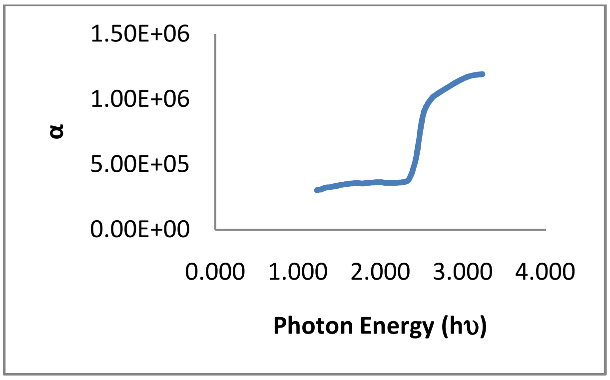

Fig. 5c The absorption Coefficient of CdS thin Film as a function to the wavelength t=4379µm

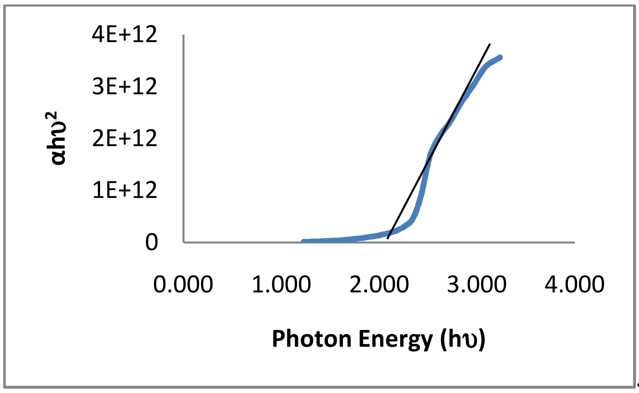

Fig. 6a The optical energy gap for the direct allow transition of CdS thin Film t=2289µm

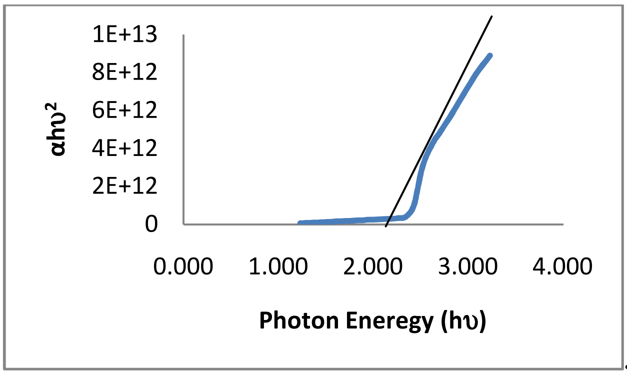

Fig. 6b The optical energy gap for the direct allow transition of CdS thin Film t=2989µm

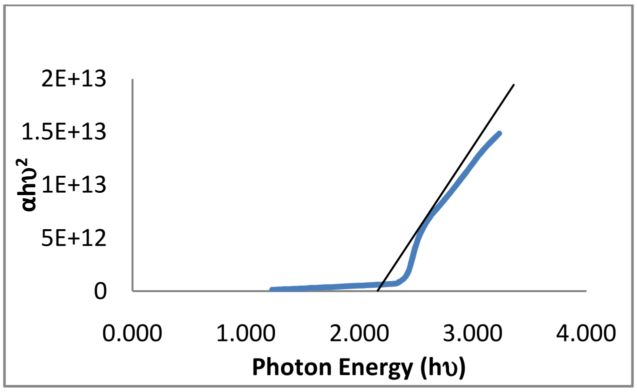

Fig. 6c The optical energy gap for the direct allow transition of CdS thin Film t=4379µm

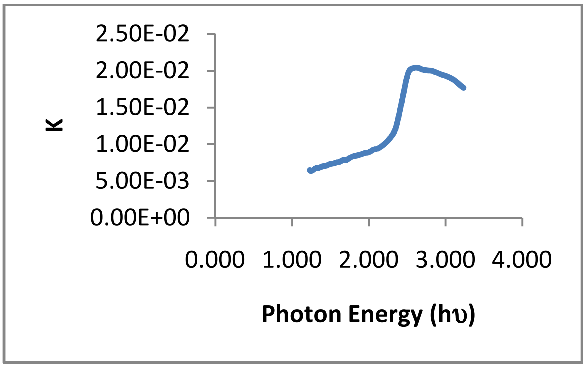

Fig. 7a The extinction Coefficient of CdS thin Film as a function to the Photon Energy t=2289µm

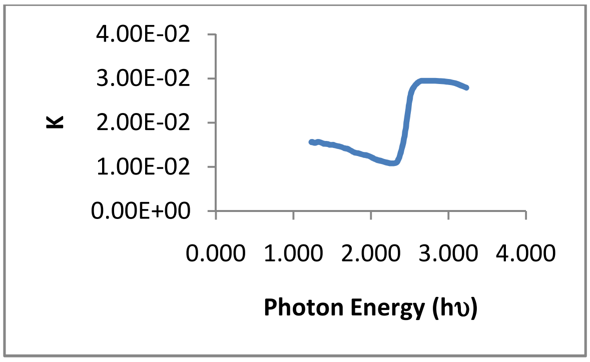

Fig. 7b The extinction Coefficient of CdS thin Film as a function to the Photon Energy t=2989µm

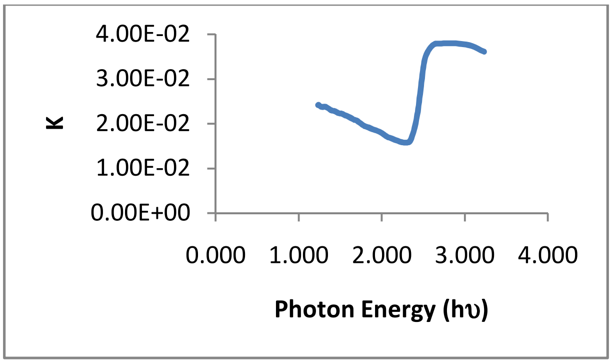

Fig. 7c The extinction Coefficient of CdS thin Film as a function to the Photon Energy t=4379µm

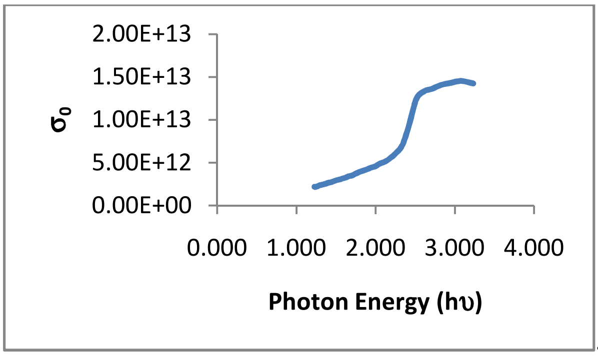

Fig. 8a The Optical Conductivity of CdS thin Film t=2289µm

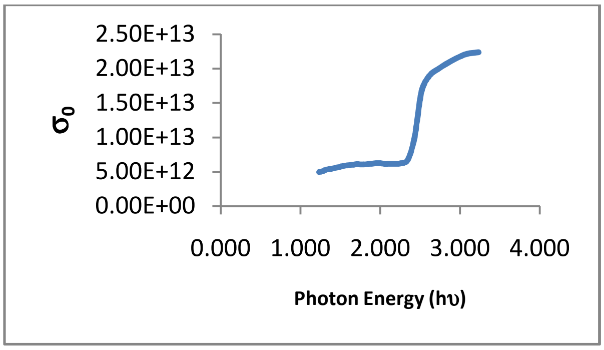

Fig. 8b The Optical Conductivity of CdS thin Film t=2989µm

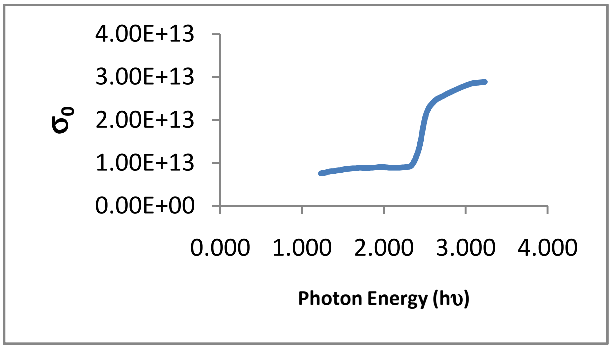

Fig. 8c The Optical Conductivity of CdS thin Film t=4379µm

The optical absorbance spectra of CdS thin films deposited by Spray Pyrolysis are shown in fig. 3a, 3b & 3c the optical band gap can be estimated by using the relation.

$$\alpha h\upsilon = A(h\upsilon - Eg)^n$$

Where Eg is the band gap corresponding to particular transition occurring in film, A is a constant, υ is transition frequency and the exponent n characterizes the nature of band transition. The graph between hυ Vs. $(\alpha h\upsilon)^2$ plotted and shown in fig 6a, 6b, and 6c the extrapolation of straight line to $(\alpha h\upsilon)^2 = 0$ axis gives the value of energy band gap of CdS thin films. The band gap of thin films were found 2.42 eV for thin film with thickness t= 2289 µm, 2.39 eV for thin film with thickness t = 2989 µm and 2.36 eV for thin film with thickness t=4379 µm for spray deposite film. The CdS thin films shows average absorption coefficient (α) of about 2.29 x 10^5 cm^{-1} for the thin film with thickness 2289 µm, 3.54 x 10^5 cm^{-1} for the thin film with thickness 2989 µm and 4.93 x 10^5 cm^{-1} for the thin film with thickness 4379 µm near the absorption edge. This shows that the deposited semiconductor films are direct band gap material (Sze 1969) [20]

CONCLUSION

CdS films were deposited by a spray pyrolysis technique using a solution of cadmium sulphide and thiourea. The films were deposited onto. Glass substrate at the selected temperature 300^0C. Substrate temperature during deposition was found to have influenced the phase. The films has good optical quality properties and are well-suited for Solar Cell applications. The films exhibited a direct transition 2.42 eV, 2.39 eV and 2.36 eV These results suggest that the method of spray pyrolysis for the deposition of CdS thin films should be further investigated for application towards the fabrication of solar cells. The optical properties of CdS thin films were studied using transmittance spectra. The refractive index and the optical gap of the material can be controlled by the deposition conditions.

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