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Opto-electronic properties of nanostructured CdS thin film grown by chemical route

Taur Vidya S and Sharma Ramphal

Thin Film and Nanotechnology Laboratory, Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad 431004,
E-mail: rps.phy@gmail.com

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ABSTRACT

In present study, we report on the nanostructured CdS thin films synthesized at an optimum low temperature on glass substrates using cost effective chemical method for photosensor applications. The as-deposited nanostructured thin films were characterized for optical and electrical properties. The optical transmittance spectrum indicates high transmission (~ 60 %) with direct energy band gap of 2.42 eV. The thermoelectric power (TEP) measurements confirms the n-type conductivity of the nanostructured CdS thin film. The I-V studies show significant increase in photo response (~ 96 %) of the nanostructured thin film on illumination with light source of 100 mW/cm^2.

Keywords: Nanostructured; thin films; electrical conductivity; photoresponse.

INTRODUCTION

Cadmium sulphide is one of the members of II-VI group which has maintained its identity as photosensor device, particularly in solar cell. CdS is n-type semiconductor with direct band gap of 2.42 eV [1]. In general, the high energy band gap material is used as window material associated with p-type radiation absorber layer whose band gap ranges between 1.1 eV to 1.5 eV to form hetero-junction configuration. These two opposite conductivity (n and p) semiconductor materials in heterojunction are referred as absorber layer and window layer respectively having band gap difference of $Eg_2 > Eg_1$ [2]. The higher band gap of CdS thin film enhances the performance of solar cell by omitting the absorbance loss [3,4].

METHODOLOGY

The CdS thin films have been synthesized by simple, cost effective chemical route on glass substrate. The growth parameters such as pH, molarities of the reactants, temperature of the bath and the reaction time were optimized to obtain large area uniform deposition over the entire substrate. The as–deposited CdS thin films are characterized for optical and electrical properties. The optical characterization (absorbance and transmittance as a function of wave-length) were performed using UV–Vis spectrophoto-meter (Perkin Elmer, Lambda 25). Thermo electric power (TEP) measurements were perform to know the type of conductivity. The Current–Voltage (I–V) characteristics were measured using Lab equipment (model no. 2004) interfaced with computer. Silver (Ag) contacts were prepared on thin film by vacuum evaporation technique to ensure good ohmic contacts.

RESULTS AND DISCUSSION

Optical analysis:

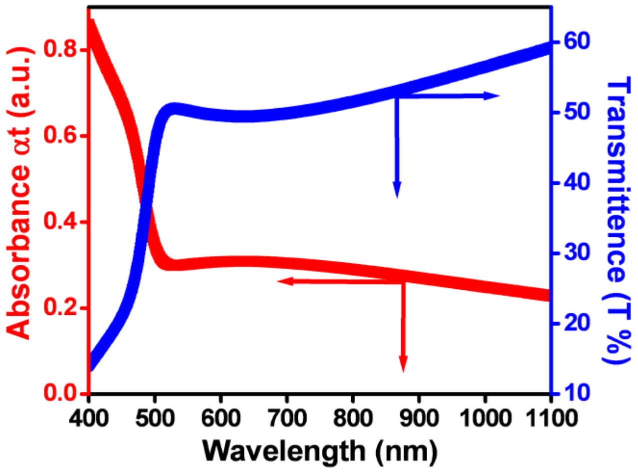

Fig. 1 Energy band gap of nanostructured CdS thin film.

Fig. 1 shows the plot of optical transmittance and absorbance against the wavelength of light for CdS thin film deposited on glass substrate. Optical transmittance of 60% is observed for higher wavelength of light, which is one of the prerequisite for optoelectronic devices particularly as solar cell window layer [5, 6].

Where, '*hν*' is the photon energy, '*A*' is constant. E_g is energy band gap. The exponent n is 0.5 for direct allowed and 1.5 for direct forbidden, 2.0 for indirect allowed and 3.0 for indirect forbidden transition. Fig. 6 shows plot of $(ahv)^2$ versus hv for calculation of energy band gap. The presence of only one slope in the curve indicates single phase with direct allowed transition. The band gap energy of the thin film is determined by extrapolating the linear portion of plot of $(ahv)^2$ versus *hv*. The calculated band gap of the film Eg = 2.42eV is in good agreement with that reported in literature [5].

Electrical analysis:

TEP measurements: The nature of conductivity of the CdS thin film is decided by performing the thermoelectric power measurement. The Fig. 2 shows the plot of thermo emf against the temperature.

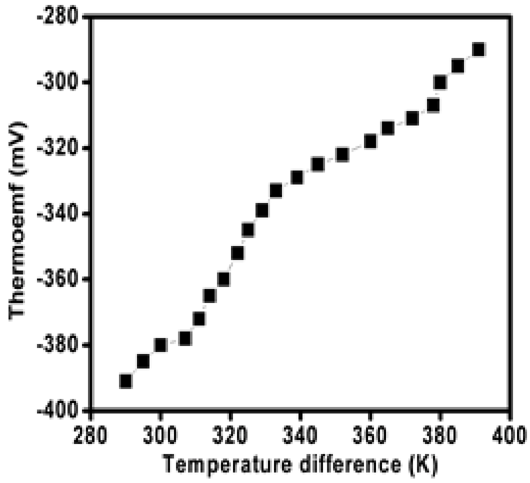

Fig. 2. Graph of thermo emf versus temperature of nanostructured CdS thin film.

From the plot it is observed that the emf of the thin film increases as the temperature is increased. Thermo electric power (TEP) is found to be 13.96 mV/°C calculated from the slope of the graph. In addition to this the polarity of the thermoelectric voltage of CdS film is positive towards the hot end, which indicates that the CdS exhibits n-type conductivity.

I-V measurements: I-V graph of nanostructured glass substrate CdS thin film is shown in Fig. 3 under dark and illumination condition.

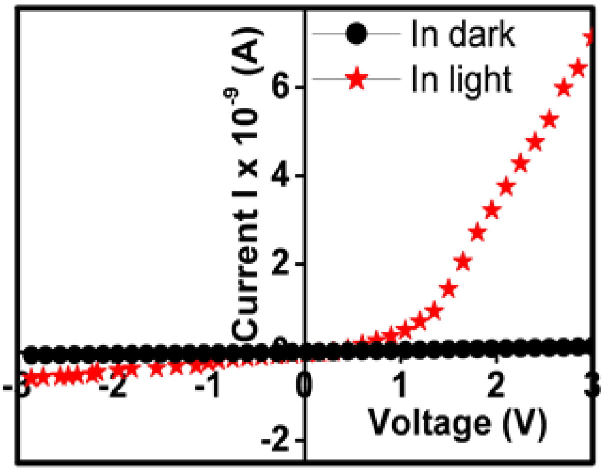

Fig. 3: I-V plot of nanostructured CdS thin film under dark and illumination.

The I-V curve shows that the current increases nonlinearly with the applied bias, Furthermore, the conductance of the CdS thin film in dark is noted to be poor, however when the thin film is exposed to light the conductivity is enhanced. Here the resistance of the thin film under dark and illumination condition is measured this change in the resistance is proposed as the photoresponse calculated using the following relations, the photoresponse is observed to be ~ 96 % where, S is the photoresponse, R_d and R_L is the resistance under dark and illumination condition.

CONCLUSION

Nanostructured CdS thin films were successfully grown on glass substrate with good crystalline quality by using soft chemical route at lower temperature. These CdS thin films were characterized for optoelectronic properties. From the optical study, the transmittance was observed to be 60% and the energy band gap derived was 2.42eV. The morphological analysis revealed leaf-like rough structure which might be useful for harvesting the light. The photoresponse calculated from the I-V plot is found to be 96%. The above discussed characteristics of nanostructured CdS thin film confirm its utility as a window material for solar cell applications.

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Conflicts of interest: The authors stated that no conflicts of interest.

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