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Synthesis and study of CDS material by CBD Method

[1] Vishakha N. Dhanwate, [2]Dr. N. D. Sali

[1][2] Department of Physics, PVP College of Arts, Science and Commerce, Loni, India
[1]Dr. D. Y. Patil Institute of Technology, Pimpri, Pune

*Corresponding Author E-mail: itsmevishakha.vp@gmail.com

Abstract: Solar Cell devices are most trending and exciting topic for the researcher as development is always associated with energy, and solar cell is best solution for energy crisis. Therefore, solar devices are considering as best solution by any manner, because of its availability in countries like India. But it is not said to be always easy to deal with it and take paybacks of this free availability of the resource. Generation of solar energy is essential in engineering growth and innovations. utilization of sun's energy for growth of technology and for future need are core task for this generation's researcher. Hence overall learning of solar cell is very crucial for progress of technology and for progress of mankind as well. Cadmium Sulfide, films were synthesized by chemical bath deposition (CBD) by using solution of containing cadmium Chloride, ammonium Chloride, thiourea, and ammonium hydroxide. The XRD pattern of CdS shows the wurtzite structure with plane (0 0 2), (101) plane of orientation. The band gap of the CdS material was obtained by calculations of UV from the data absorbance and transmittance, which was observed roughly 2.4 eV with undeviating morphological nature of material.

Keywords Solar Cell, Cadmium Sulfide, CBD, XRD, Nanoparticles

1. Introduction

In twenty first century, researchers are focussing on technological output by using knowledge of thin film and material science. Polycrystalline natured CdS material is early establishing the attention of researcher which plays vital role in growth of photovoltaic technology. CdS is assumed as a best a companion of various materials like Cu_2S, $CuInSe_2$, and CdTe for growth of solar cell devices. Cadmium sulfide (CdS) is very popular research among the researcher in all over the world for investigation of thin film characterization and Fabrication of solar cell devices in the last five decades [1]. The CdS material achieved highest attention in homo as well as hetero junction companion of materials of solar cells [2]. CdS material in thin film as well as nano form is supposed to be most eligibly fitted material for window layer in various processes of fabrication of solar cells. CdS is obtained from the periodic group II-VI which forms semiconducting compound, which resembles its characterization very much with ZnS [3]. Its characteristic is always associated with direct band gap nature which will be roughly 2.4 eV at room temperature. CdS material is observed mainly in two types of crystalline structure phases, one is cubic and other is hexagonal which is said to be wurtzite phase of the structure. In CBD deposition technique, the properties of the any films are inclined by the many parameters like compositional concentrations in the bath of precursors, temperature of the solution and pH of the solution. Chemical bath deposition (CBD) method is widely and popularly used for synthesis and development of semiconductors which has extensive applications [4]. CBD method is considered and proved most suitable and low cost technology which has numerous industrial applications as well.

Why CdS Material:

- Element from II-IV periodic group
- n-type conductivity
- wind and direct band gap 2.45 eV
- Wurtzite Structure
- Cost Effective
- Ability of fast transformation of photo-generated charge carriers

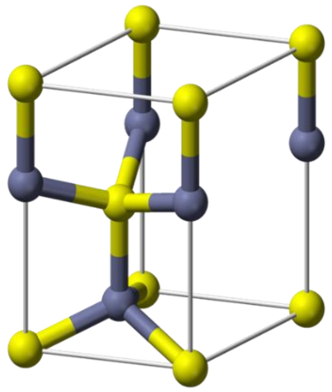

Fig. 1: Crystal structure for CdS

2. Experimental Details

On experimental Workfront of synthesis of CdS material, there are several techniques used by researcher. CdS material in the form thin films were placed on a substrate by using chemical bath deposition (CBD) method [6]. In the process of synthesis of CdS material, bath solution of CdS is made up by using 6.5 mM $CdSO_4$, 0.7 M NH_4Cl and 0.25 M thiourea. Further we have used Ammonia solution for optimizing pH of the bath solution at 50 ^{0}C. Further temperature of the solution reached to approximately 80 ^{0}C, CdS material were obtained on ITO coated glass substrate after 10 minutes of continuous deposition. For the improvement of characteristics of solar cell, CdS material were heated or annealed in oven 400 ^{0}C for 20 minutes.

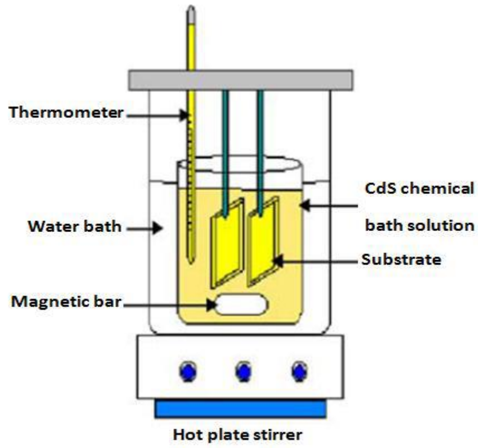

Fig. 2: Experimental set up for CdS deposition.

The as-prepared and annealed/heated CdS material were studied by characterization techniques of X-ray diffractometer, UV-Visible spectroscopy, Scanning Electron Microscopy and Atomic Force Microscopy.

3. Result and Discussion

The crystallographic structure can be characterized with the help of X-ray Diffractometer. Structural properties of as-synthesized CdS material and heated CdS material is observed through 2θ versus intensity measured by XRD.

Xray diffraction pattern of CdS consists CdS (002) and (101) plane corresponds to angle 26.6^0 and 29.12^0 respectively which shows oriented wurtzite structure. After heating treatment of CdS material at 400^0C for almost 20 minutes, the CdS material shown same prominent peaks as like as-synthesized CdS material [7]. X-Ray diffraction pattern that is 2θ versus intensity plot for the as-synthesized (a) and heated (b) CdS material is shown in fig.1

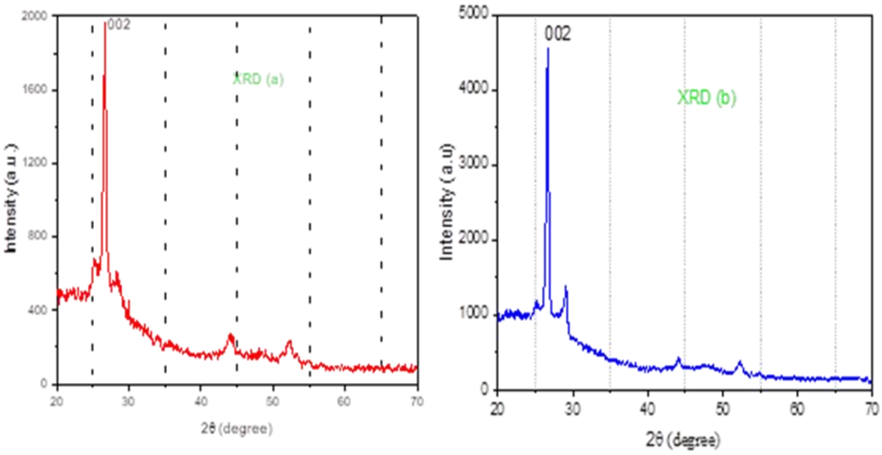

Fig.3: XRD graph of as-synthesized CdS (a) and annealed CdS (b)

The size of the grain of as-synthesized and heated CdS material were calculated by using the formula gained from Scherrer equation [5],

$$t = \frac{0.9\,\lambda}{\beta\cos\theta}$$ --------------------------------[1]

Where

λ=Wavelength of Xray source= 1.5418.

θ = diffraction angle.

β =FWHM

FWHM of as-synthesized CdS material was 0.4526 and was 0.3706 for heated CdS material.

By substituting corresponding values from plot in equation [1] we were able to obtain grain size of the samples.

Calculated grain sizes of as-synthesized CdS material and heated CdS material were 34nm and 41 nm respectively.

The optical characterization can be carried out by using UV-VIS Spectrophotometer. Fig.2 shows the graphical presentation of optical absorption versus photon energy for as-synthesized material (a) and heated CdS material (b).

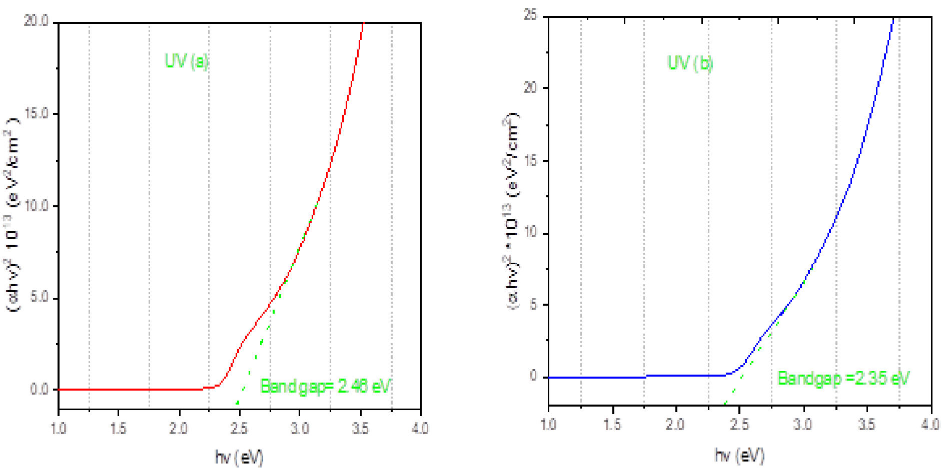

Fig.4: optical absorption graph of as-synthesized CdS (a) and heated CdS (b)

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The study of absorption coefficient and band gap of the material can be obtained by using the equation,

$$(\alpha h\upsilon)^2 = \alpha_0 \ (h\upsilon - E_g)$$

E_g =Band gap energy
$h\upsilon$= The energy of incident photon
α_0 =constant

The band gap of semiconducting material can be derived with the help of graph of $(\alpha h\upsilon)^2$ verses $h\upsilon$. Energy band gap obtained for the as-synthesized CdS material was observed nearly closed 2.46 eV which is very much approximation with literature value. After heating treatment many times minute growth in grain size was observed which gave rise to decrease in band gap. The band gap heated CdS material was reduced from 2.46 to 2.35 eV. This change in band gap is due to the increase in particle size which can be explained by calculated grain sizes of as-synthesized and heated CdS material [6].

The Surface morphology of material can be studied out with the help of scanning electron microscope (SEM) with accelerating voltage 20 kV and probe current 1 nA. The Morphology of CdS particle was observed through SEM images, fig.3 represents the SEM images of as-synthesized CdS material (a) and heated CdS material (b).

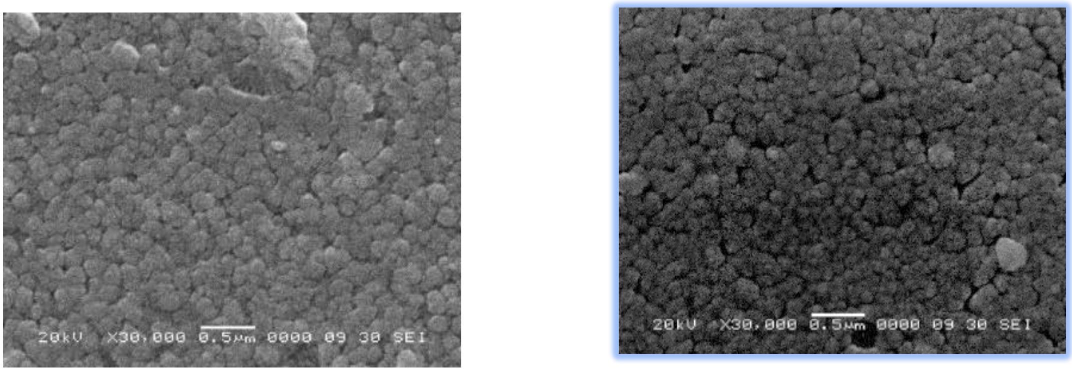

Fig.5: Morphological imaging by SEM as-synthesized CdS material (a) and heated CdS material (b)

Throughout uniform and closely packed compact CdS material were obtained by using well defined chemical bath deposition technique. Sometime surface morphology of CdS material was not clear maybe because of the extremely resistive CdS layer. Therefore, improvement in the morphology upon thermal treatment could be seen in the AFM images [8].

With the aim of study of morphology of as-deposited and annealed CdS thin films, atomic force microscopy images were recorded. Fig.4 represents the as-synthesized CdS and heated CdS material.

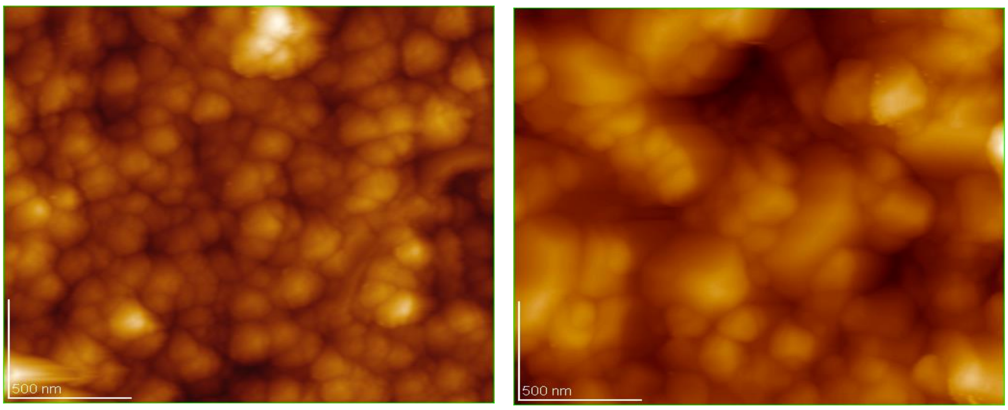

Fig.6: morphological imaging by AFM as-synthesized CdS material(a) and heated CdS material (b)

AFM verifies the uniform, compact and well adherent nature of CdS material on the conducting glass substrate. As-synthesized material showed spherical morphology, after heating there is enlarged grain size was observed. These properties of CdS material will be very advantageous for fabrication of good solar cell [9].

4. Conclusion

Chemical bath deposition is one of the best low-cost methods for synthesis of CdS material. Uniform, compact and well adherent CdS material were synthesized on ITO coated glass substrate. After heating treatment prominent enhancement in characterization was observed. Highly crystalline wurtzite CdS layer showed (002), (101) in its crystal structure. The optical absorption spectra of the as-synthesized and heated CdS material were observed appropriately good for solar cell fabrication. This will surely enhance the Fill factor and ultimately efficiency of solar cell.

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