Synthesis and characterization of cadmium sulfide nano particles

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Abstract*: *The structural, optical and electrical properties of cadmium sulphide (CdS) thin films. Structural identification was done by XRD method at 2θ lying between 0º and 80º. The XRD results showed that the deposited films were polycrystalline with cubic structure having the plane as preferred growth. SEM was utilized in the morphological study of the films. The optical characteristics of CdS deposited on the glass substrate have been investigated from the absorption spectrum with wavelength from 350 to 600 nm. Further, optical constants were studied using UV-Visible absorption spectrum. The dielectric constant and dielectric loss of CdS thin films were found at various temperatures between 50 Hz to 5 MHz. The dielectric constant was evaluated as a function of frequency at various temperatures. The activation energy was determined and was about 0.24eV. Photoconductivity study established the nature of positive photoconductivity of CdS thin films.

Index Terms*: *Cadmium Sulfide nano particles.

1 INTRODUCTION

The science and technology of thin film plays a considerable role in hi-tech industries. The necessity for the development of miniature devices that operates at greater speed, which can be used particularly for the integrated circuits of new generation, involves advanced materials and new processing methods appropriate for integration technology. Owing to the innumerable applications and their uses in various fields like the electronic industries, military weapon systems, space science, solar energy utilization, optical, superconducting, high memory computing, sensors and in microelectronic and hybrid circuits thin film science has obtained remarkable attention. Semiconducting thin film materials have brought about immense attention in the field of optoelectronic technology.They find an immense purpose in the photovoltaic applications because of their optical properties that depends mainly on the size and the tunable spectrum that is invisible to the IR. For such type of applications, II–VI group semiconductor nano particles are extensively utilized. The use of nanotechnology in the synthesis of thin films signifies extraordinary development in its efficiency and reduced total cost. Because of their potential applications in photo voltaics numerous nano-structured materials are being studied recently.

Revised Manuscript Received on April 07, 2019

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2 EXPERIMENTAL SECTIONS

2.1 Materials

Analytical Reagent (AR) grade of Cadmium nitrate Cd(NO3)2, sodium sulfide (Na_2S) were bought from Sigma-Aldrich. All these solutions were prepared using Milli-Q water (pH 7.2).

2.2 Preparation of Cadmium sulfide nanoparticles

For the synthesis of CdS nanoparticles, (0.1 M) Cd(NO3)2 and 50-mL aqueous solution of (0.1 M) Na2S were prepared. The freshly prepared aqueous solution of 0.1 M Na2S was mixed drop by drop in the 0.1 M CdNO3 solution using strong stirring for 3 hours after the completion of reaction this will turns into dark yellow. were washed with ethanol and centrifuge for several times and were dried at 70 C 3hours in vacuum.

2.3 Materials Characterization

After preparing the Cds,the Cadmium sulphide is subjected to various characterization techniques such as **Xrd, Ftir, Uv, Raman, Pl, Thermal and SEM analysis.**

3. RESULTS AND DISCUSSION.

3.1 Structural analysis.

Structural identification of CdS films was performed using XRD at a range of angle 2θ lying between 0º and 80º. Figure 7.1 exhibits the XRD patterns for Cadmium sulfide thin films that are nano crystalline in nature. The analyzed broad hump occured in XRD pattern is because of the amorphous glass substrate. The well-defined (111), (220), and (311) peaks are found from the XRD patterns. The (111) peak corresponds to the phase of polycrystalline CdS. The strong and sharp diffraction peaks specify well crystallized sample formation. It isobserved that the major peak (111) is dominating the other peaks. The CdS deposited possessed a structure that was predominantly cubic and reasonably crystalline. The results of XRD shows the CdS thin films deposition that is polycrystalline in nature with cubic structure having (111) as the preferred growth plane. The average grain size determined from X-ray line

Debye-Scherrer and Broadening peak equation was about 15.3 nm.

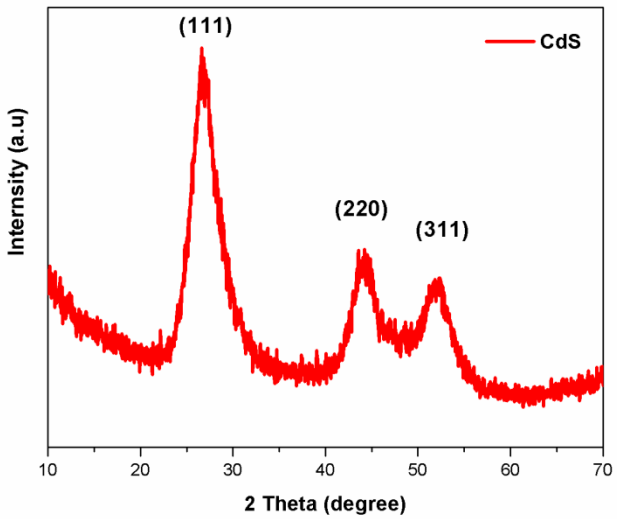


Fig. 1 XRD patterns of CdS nanoparticles

3.2 FT-IR analysis

The FTIR spectrum of pure CdS is as shown below.(fig.2)the energy region where it is high shows the peak of 39343.3cm-1 is assigned to O-H stretching of absorbed water on the surface of CdS.It is evidence that the presence of water is confirmed by its bending vibration a2055.75cm^{-1} The peak at 1526.5 is defined to bending vibration of methanol used in the process. It is also verified by its CH3-stretching vibrations which occurring as very weak peaks just below 3000 cm-1.The C-O stretching vibrations occurs as very intensive peak at 1004.73cm^{-1}.The weak peaks due to C-H stretching were observed at 532.5cm^{-1}.So the aborbed methanol on the surface of, presence of thiophenol in its dissociation form is also evident.

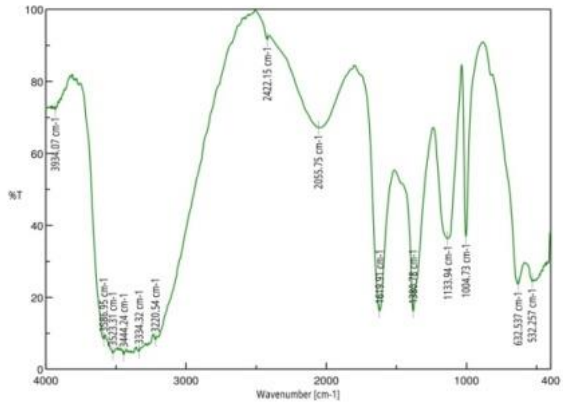


Fig. 2 FTIR spectrum of CdS nanoparticles

3.3 Uv-vis absorption spectra analysis

Determination of Optical Constant UV-Visible absorption spectrum was used to estimate the optical constants. The optical constants were determined using the relations below and tabulated in Table.1.1.

The optical constants is found by

$$\varepsilon_r = \varepsilon_0 + 4\pi\chi_C = n^2 - k^2 \quad \text{-1.1}$$

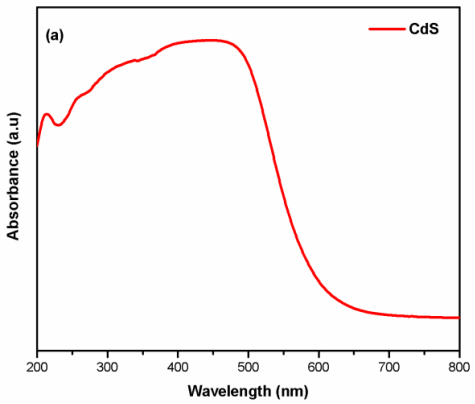
Where ε_0 is the permittivity of free space.

The electric susceptibility (χc) was calculated and it was 4.29 at λ=1400 nm. It is clear that the material is easily polarizable, provided the incident radiation is intense, for χc > 1.The formula (1.2) and (1.3) could be used to find εr and εi, which is the real and imaginary part of the dielectric constant respectively.

$$\varepsilon_r = n^2 - k^2 \quad \text{---- 1.2} \qquad \varepsilon_i = 2nk \quad \text{---1.3}$$

Parameters	value
Extinction coefficient (K) at λ =600 nm	1.43×10^{-6}
Refractive index (n) at λ =600 nm.	2.45
Electric susceptibility (χ_c) at λ =600 nm.	5.0025
Real dielectric constant (ε_r) at λ =600 nm.	3.125
Imaginary dielectric constant (ε_i) at λ =600 nm.	8.243×10^{-5}

Table 1.1 optical constants of CdS Thin films



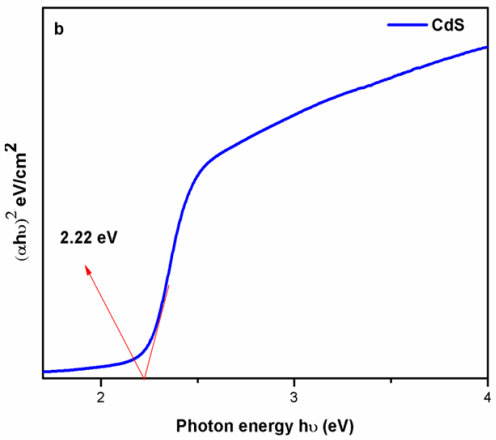
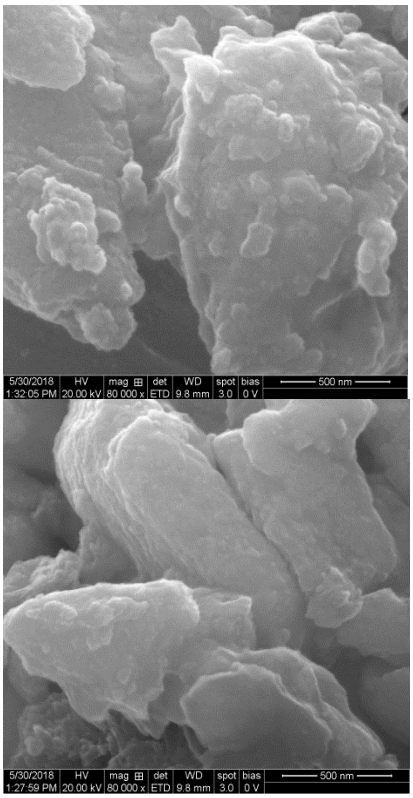


Fig.3 DRS UV-vis spectrum of (a) CdS nanoparticles (b) Optical band gap of pure CdS nanoparticles

3.8 Morphological studies

Morphological study of CdS thin film was performed using Scanning electron microscope (SEM). Figure -4 presents the SEM images of CdS thin films. The CdS thin films formed were highly agglomerated. In this image the spherical shape of CdS nanoparticles deposited is confirmed. The spherical shaped particles which have a mean grain size of ~ 15 nm are visible through the SEM analysis.



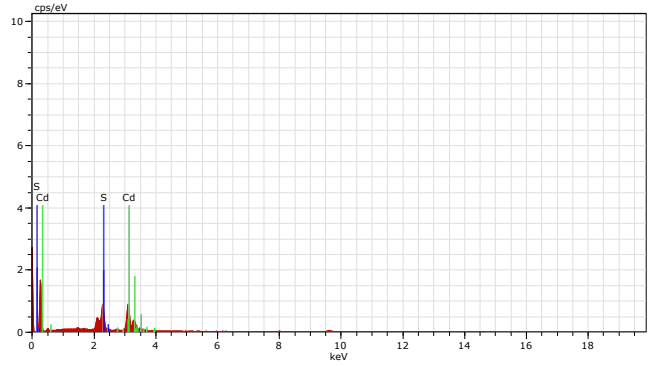


Fig. 4 SEM images of (a) CdS nanoparticles its corresponding EDAX spectrum.

4. CONCLUSIONS

The objective of this paper was to develop a cost efficient technique to fabricate the n-and p-type multilayer semiconducting thin films using CBD method. XRD studies revealed the nano crystalline range of the synthesized films; diffraction peaks were also determined. SEM were used to characterize the surface morphology of CdS thin films. The UV-Visible absorbance spectrum exhibited outstanding transmission in the visible region. The activation energy of CdS films was estimated to be 0.24eV. The optial study showed positive photoconductive nature of CdS Thin films.

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