Physical properties of CdSe nanoparticles thin film synthesized by Chemical Bath Deposition at different deposition time and different Cadmium concentration

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Abstract:
High quality nanoparticles Cadmium Selenide, CdSe, thin films were prepared by Chemical Bath Deposition (CBD) technique. In the present work the films were deposited on glass substrate at different reaction time and Cadmium concentration, using cadmium chloride as \( \text{Cd}^{2+} \) ion source and sodium selenosulphite as \( \text{Se}^{2-} \) ion source. The pH of the bath was kept constant around 11 ± 0.1. The effect of reaction time and Cadmium concentration on structure and optical properties were studied. The structural properties were studied by X-ray diffraction for all thin films where reveals a Polycrystalline nature with cubic structure having preferential orientation along (111) plane direction. The calculated crystallite size was found to be between 4.902 nm and 7.937 nm, and this indicates that all prepared CdSe thin films are nanoparticles. It was found that crystallite size increases with increasing deposition time; whereas crystallite size decreases as concentration of \( \text{CdCl}_2 \) increases. Optical properties were studied by UV-vis spectrophotometer for all films which shows blue shift in peak. The values of the energy gap (allowed direct transitions), calculated from the absorption spectra, was between 2.2 and 3 eV, in contrast to the bulk, energy gap which is 1.74 eV. Electrical resistivity of CdSe thin film as a function of thickness was measured at room temperature, by using two point probe method. It has been found that the resistivity decreases as thickness increases.

Keywords: Chemical Bath Deposition, deposition time effect, concentration of \( \text{CdCl}_2 \)

Introduction:

Semiconductors are very important and interesting because of their technological applications in optoelectronics and microelectronic devices like photodiodes [1], sensors [2], light emitting diodes [3], solar cells [4], photoelectrochemical cells [5], photovoltaic cells [6] and photodetectors for optical communications etc. Among them, Cadmium Selenide (CdSe) is a IIeVI group compound semiconducting material of the periodic table. The transition metals find greater solubility in II–VI compound semiconductors when compared with III–VI semiconductors. Among II–VI semiconductors, cadmium selenide (CdSe) is a well-known semiconductor, crystallizing in either the wurtzite or the zinc blende structure [7]. This compound is a highly photosensitive material in the visible region due to their suitable band gap (1.74 eV). Different processes such as chemical vapour deposition [8], physical vapour deposition [9], thermal evaporation technique [10], spray-pyrolysis [11], chemical bath deposition [12], dip coating [13] and electrodeposition [14] have been used for depositing cadmium selenide thin films. However, the electrodeposition process is one of the simplest and low-cost techniques because it is easy to manage and it requires very simple arrangement. Deposition rate is easily controlled by changing deposition potential, concentration and pH value of the electrolyte. Many groups are working on cadmium selenide using the process of electrodeposition [5,8,15-17]. The optoelectronic, microelectronic and other applications of cadmium selenide thin films depend on their structural and electronic properties affecting device performance. Thermal treatment is one of the important factors to enhance the efficiency and stability of photosensitive devices. Thus, studies of the effect of annealing on structural, optical and electrical properties of thin films are very important in understanding and enhancing device sensitivity [18-20]. These properties are strongly influenced by the deposition parameters such as deposition time, deposition potential, concentration of electrolytic solution, pH of the electrolyte and thermal annealing. The CBD method for the deposition of thin films from an aqueous solution is a promising technique because of its simplicity, affordability, convenience for large-scale deposition and having easily-controllable parameters such as concentration, pH, deposition temperature and deposition time, etc. The preparation conditions such as solution concentration, pH value, and deposition time and bath temperature are optimized in order to get good quality of CdSe thin films [21].

Experimental

The CdSe was deposited on substrate via CBD. Selenium powder (99.95%) was mixed with solution of sodium sulphate with ratio 1:5 (e.g., 1 gm Se with 5 gm Na₂SO₃ ), concentration of solution (Na₂SeSO₃) was kept constant around 0.23Mol. The mixture was heated under reflux at 90 °C for 3 h to form a clear Na₂SeSO₃ solution. The cadmium precursor was prepared by dissolving 0.2 M of CdCl₂ in DI water. Then, ammonia solution was added into the cadmium solution slowly to adjust the pH of the solution at 11 ±1. This was to prevent a reverse reaction of Cd (NH₃)₄²⁺ to form stable cadmium hydroxide (Cd(OH)₂). Both precursor solutions were then mixed until homogenous. The substrate was soaked vertically inclined into the CdSe bath solution for the deposition process. CdSe thin films have been deposited at various concentrations (conc.) of \( \text{CdCl}_2 \) (0.03, 0.05, and 0.07 Mol) and deposition time was varied from 60min-120 min. A digital programmable hotplate (Torrey Pines Scientific) was used in this experiment. The temperature of the chemical bath was set and, upon the deposition process, the solution’s temperature checked, using a thermometer for
confirmation. Then, the samples were rinsed with DI water and dried in an oven overnight. All chemicals materials were purchased from Schrloau Co., all the chemicals were of analytical grade and used as purchased. The dissociation relation and the equation for the chemical reaction are:

\[
2\text{CdCl}_2 + 4\text{NH}_3 \leftrightarrow (\text{Cd(NH}_3)_4)^{2+} + \text{CdCl}_4
\]

\[
\text{[Cd(NH}_3)_4]^{2+} \leftrightarrow \text{Cd}^{2+} + 4\text{NH}_3
\]

\[
\text{Se} + \text{Na}_2\text{SO}_3 \rightarrow \text{Na}_2\text{SeSO}_3
\]

\[
\text{Na}_2\text{SeSO}_3 + \text{OH}^- \rightarrow \text{Na}_2\text{SO}_4 + \text{HS}e^- \\
\text{HS}e^- + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{Se}^{2-}
\]

\[
\text{Cd}^{2+} + \text{Se}^{2-} \rightarrow \text{CdSe ↓}
\]

**Characterization**

X-ray diffraction (XRD) patterns of samples were scanned on Advanced X-ray diffractometer (Bruker, Karlsruhe, Germany) using Cu Ka radiations with wavelength 1.5405 Å. The diffraction data were recorded for 20 angles between 20° and 80°. The X-ray diffraction patterns reveal that the films are polycrystalline in nature as shown in Fig. 1. The sharp and strong diffraction peaks are in agreement with those for cubic crystal structure (JCPDS Data file NO. 19-0191, and NO. 65-28961). The diffuse reflectance spectroscopy of thin films structure were obtained by the Ultraviolet-visible spectrophotometry (UV-Vis). UV-Vis diffuse reflectance spectroscopy (UV-Vis DRS) was carried out on an UV-3010 UV-Vis spectrophotometer (Hitachi, Japan).

**Equations used in this work:**

\[
D = M\lambda/\beta \cos \theta \\
ap = d\sqrt{h^2 + k^2 + l^2} \\
n\lambda = 2d \sin \theta \\
\delta = n/\langle D \rangle \\
\varepsilon = (\beta \cot \theta)/4 \\
\alpha = 2.303 A/\lambda \\
F_{\text{shift}} - F_{\text{bulk}} = \frac{\hbar^2}{8\pi^2} \left( \frac{1}{m_q} + \frac{1}{m_h} \right) - \frac{C_6 e^2}{\epsilon r} - C_2 E_R^* \\
\sigma \propto \exp \left(-\frac{E_a}{K_BT} \right) \\
\rho = (\pi t/2) R \\
t = (w_i - w_o)/(A' \times d)
\]

Result and Discussion

Structural Analysis

X-ray diffractogram of CBD CdSe thin films deposited on glass substrate at different deposition time have been shown in Figure (1). Therefore, it has been concluded that the deposited CdSe thin films are polycrystalline in nature with cubic (type zincblende) structure having (111) as preferred orientation [24]. From the position of diffraction peaks and by the Bragg condition, d-spacing has been evaluated, which coincide well with the JCPDS data [22, 23], Table (1), and earlier reports [25-76]. The presence of a cubic structure may be due to the slow stirring applied during the growth process as supported by earlier workers. The dominant peak (1 1 1) has been already reported as prominent peak for CBD CdSe thin films. The lattice parameter (a) has been calculated using the Eq. (2.2). The estimated lattice parameter of CdSe thin films are in good agreement with the JCPDS data, Table (1). Broad nature of the XRD peaks could be attributed to the nano-crystalline nature of CdSe particles, which was consistent with the result from the earlier work. The values of FWHM "β" has been evaluated from the highest intensive diffraction peaks (1 1 1). The values of β decrease as deposition time increase owing to increase in the crystalline and particles size. The Grain size (D), dislocation density "δ" and strain "ε" were calculated by considering high intensive diffraction peaks of the deposited films. The calculated grain size lied between 6.764 nm and 7.479 nm (Table (1)) and this values are approach to the value of Bohier's excitonic radius of bulk CdSe (ns=5.6 nm), the grain size "D" increase with increase in deposition time (from 60 to 100 min) owing to the aggregation or coalescence of small nanocrystalline particles [28, 29]. The X-ray diffraction spectra have taken for CdSe films deposited on quartz substrate at various concentrations (conc.) of CdCl2 (0.03, 0.05, and 0.07 Mol.). Effect of concentration(CdCl2) on structure of prepared CdSe thin films has been studied. All the deposited thin films found to be polycrystalline in nature. The XRD pattern shows the reflections of the cubic fluorite structure type, Fig. (2). The observed d-spacing and the respective prominent peaks correspond to reflection from the (1 1 1), (2 2 0) and (3 1 1) planes, which coincide well with the JCPDS data and previously published papers [30-36]. These observations show out of plane (perpendicular to the substrate) orientation of the thin film with (1 1 1) preferred orientation. The position of the prominent peaks in the diffraction patterns correspond to their respective positions in the JCPDS data. The estimated lattice parameter (a) of CdSe thin films are in good agreement with the JCPDS data, Table (2). The Values of FWHM "β" has been evaluated from the highest intensive plane represent (1 1 1), where found the values of FWHM increase as concentration of CdCl2 increase Table (2). The Grain size is determined from the XRD peaks by using Scherrer’s formula [1]. The calculated grain size lied between 6.462 nm and 7.479 nm, the grain size "D" decrease with concentration of CdCl2 increase. The strain may also alter the physical properties of the thin film. The strain (ε) was estimated, and dislocation density (δ) has been evaluated; and tabulated in Table (2). The prepared CdSe nanoparticles “powder” at various concentrations (0.05 and 0.07 Mol.) were investigated using XRD technique. Figure (3) shows XRD pattern of CdSe nanoparticles of different concentrations and can be seen that the clearly appear peaks corresponding to (111), (2 2 0), (3 1 1) which coincide well with the JCPDS data [22, 23]. XRD pattern showed that the CdSe nanoparticles were polycrystalline in nature with cubic structure having (1 1 1) plane as the preferred orientation. It was observed that the plane (1 1 1) appeared with higher peak intensity in all the diffractograms, as the concentration increase the intensity increase. The constant of lattice "a" was calculated see Table (3). Values of FWHM "β" of the strong peak corresponding to the characteristic (1 1 1) plane are tabulated in Table (3). Increase in FWHM of the peak with increase in the concentration shows improvement in crystalline of the CdSe nanoparticles. The calculated crystalline size (Grain size) were
found 4.902 nm and 5.683 nm. The grain size "D" was decrease as concentrations of cadmium chloride increase from 0.05 Mol. to 0.07 Mol. The strain (ԑ) was estimated, and dislocation density (δ) has been evaluated; and tabulated in Table (3).

Table 1
Structural parameters of CdSe thin films at different deposition time.

<table>
<thead>
<tr>
<th>Deposition time (min.)</th>
<th>20 (deg.)</th>
<th>d (nm)</th>
<th>a (nm)</th>
<th>β (rad.)</th>
<th>D (nm)</th>
<th>ԑ × 10³</th>
<th>δ × 10¹²</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>25.311</td>
<td>0.352</td>
<td>0.609</td>
<td>0.021</td>
<td>6.764</td>
<td>5.1</td>
<td>2.186</td>
</tr>
<tr>
<td>80</td>
<td>25.351</td>
<td>0.351</td>
<td>0.608</td>
<td>0.020</td>
<td>7.103</td>
<td>4.9</td>
<td>1.982</td>
</tr>
<tr>
<td>100</td>
<td>25.490</td>
<td>0.349</td>
<td>0.605</td>
<td>0.019</td>
<td>7.479</td>
<td>4.6</td>
<td>1.788</td>
</tr>
</tbody>
</table>

Table 2
Structural parameters of CdSe thin films at different Concentration.

<table>
<thead>
<tr>
<th>Concentration CdCl₂ (Mol.)</th>
<th>20 (deg.)</th>
<th>d (nm)</th>
<th>a (nm)</th>
<th>B (rad.)</th>
<th>D (nm)</th>
<th>ԑ × 10³</th>
<th>δ × 10¹²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.03</td>
<td>25.490</td>
<td>0.349</td>
<td>0.605</td>
<td>0.019</td>
<td>7.479</td>
<td>4.6</td>
<td>1.788</td>
</tr>
<tr>
<td>0.05</td>
<td>25.510</td>
<td>0.349</td>
<td>0.605</td>
<td>0.020</td>
<td>7.105</td>
<td>4.9</td>
<td>1.981</td>
</tr>
<tr>
<td>0.07</td>
<td>25.731</td>
<td>0.346</td>
<td>0.599</td>
<td>0.022</td>
<td>6.462</td>
<td>5.4</td>
<td>2.39</td>
</tr>
</tbody>
</table>

Table 3
Structural parameters of CdSe powder at different Concentration.

<table>
<thead>
<tr>
<th>Concentration CdCl₂ (Mol.)</th>
<th>20 (deg.)</th>
<th>d (nm)</th>
<th>a (nm)</th>
<th>β (rad.)</th>
<th>D (nm)</th>
<th>ԑ × 10³</th>
<th>Δ × 10¹²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>25.37</td>
<td>0.351</td>
<td>0.607</td>
<td>0.029</td>
<td>5.638</td>
<td>6.1</td>
<td>3.096</td>
</tr>
<tr>
<td>0.07</td>
<td>25.72</td>
<td>0.346</td>
<td>0.600</td>
<td>0.025</td>
<td>4.902</td>
<td>7.1</td>
<td>4.162</td>
</tr>
</tbody>
</table>

Fig. (1): XRD patterns of CdSe thin films at different deposition time.
Optical Analysis

The optical properties of Chemical Bath Deposition CdSe thin films Table (4) were measured by using UV-vis spectrophotometer (Varian 50) at room temperature in the wavelength range 300-1100 nm. As shown in Fig. (4), the effect of deposition time on the absorption of CdSe thin films are observed blue shift, which indicates the effect of quantum confinement. This figure shows that the nucleation occurred within a minutes and crystals were continuously growing during reaction period. In the case of CdSe, the band-edge absorption is well-known to depend strongly on the size and the size distribution of nanocrystals, and thus we use this property to examine the growth processes as reported earlier [27, 29, 30]. The optical absorbance value increase with time reaction, which show the improvement in crystallinity. From absorption spectra the absorption coefficient ($\alpha$) was calculated using Eq. (7). The increase in "$a$" Figure (5), may be due to the smaller crystallite size of prepared film (4.2-5 nm), Table (4.11). Energy gap values of chemical bath deposition CdSe thin films were determined from the plot of $(\alpha h\nu)^2$ vs. $h\nu$. Figure (6) shows a plot of $(\alpha h\nu)^2$ vs. $h\nu$. The linear dependence of the plots indicates that the types of transition in the prepared films are direct. The direct band gap energies were estimated by extrapolating the straight portion of the curve to zero absorption coefficients. The band gap energies obtained for the CdSe films of different deposition time are in the range 2.35-2.6 eV, Table (4), which are in good agreement with the earlier reports [28-30]. It's clear that the values of energy gap of prepared CdSe thin films greater than energy gap of CdSe in bulk (1.74 eV). The decrease in energy gap with increase in deposition time (thickness increase) can be attributed to increase in the grain size, which leads to stabilization of the energy gap at 2.35 eV. Lower time reaction (lower thickness) films have a high optical energy gap (2.58 eV). Such an increase in the energy gap of chemically deposited CdSe thin films have been reported earlier [31-35]. It can be seen from figure (7) variation of energy gap with deposition time. The average radius of CdSe nanoparticles can be estimated by using Brus's formula, Eq. (8), where found the experimental values lied between 4.224 nm and 4.957 nm, this values close to Bohr's Excitonic radius of bulk CdSe ($a_B=5.6\text{nm}$) and this indicate that the prepared films are quantum dots. It observed increasing in particle size with deposition time increase as shown in figure (8). Table (4) shows the experimental values of energy gap, blue shift and particles size.

The optical absorption spectra studies of prepared CdSe thin films on glass substrates with different concentration of CdCl$_2$, table (5), were measured in the wavelength 300-1100 nm at room temperature. Fig. (9), shows effect of concentration on absorption spectra of prepared films. It can be seen that slight shift to lowest wavelength and suddenly increase in the UV region of absorption spectra of films with increasing cadmium chloride concentration. The optical properties are strongly dependent on particle size. The calculated absorption coefficient $(\alpha)$ plotted vs. wavelength $(\lambda)$, it’s clear that a increase with cadmium chloride concentration increase, as shown in figure (10). The calculated absorption coefficients $(\alpha)$ found to be of order $10^5 \text{cm}^{-1}$ in the CdSe thin films of different concentration of CdCl$_2$. Figure (11) shows a plot of...
The estimated values of energy band gap lie between 2.58 and 2.75 eV. It’s observed that the energy gap increases as concentration of cadmium chloride CdCl₂ increase. Figure (12) shows variation energy gap with concentration of cadmium chloride CdCl₂. The estimated values of particles size, Table (5), is approach to Exciton Bohr radius for bulk CdSe, this indicate that the prepared films are quantum dots. It’s found that increase in particles with decrease in concentration of CdCl₂, figure (13). Table (5) shows the experimental values of energy gap, blue shift and particles size.

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Deposition time (min.)</th>
<th>Energy gap $E_g$ (eV)</th>
<th>Blue shift $E_{shift}$ (eV)</th>
<th>Particle size D (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z1</td>
<td>40</td>
<td>2.58</td>
<td>0.84</td>
<td>4.224</td>
</tr>
<tr>
<td>Z2</td>
<td>60</td>
<td>2.48</td>
<td>0.74</td>
<td>4.501</td>
</tr>
<tr>
<td>Z3</td>
<td>80</td>
<td>2.4</td>
<td>0.66</td>
<td>4.765</td>
</tr>
<tr>
<td>Z4</td>
<td>100</td>
<td>2.35</td>
<td>0.61</td>
<td>4.957</td>
</tr>
<tr>
<td>Z5</td>
<td>120</td>
<td>2.4</td>
<td>0.66</td>
<td>4.765</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample name</th>
<th>Concentration $CdCl_2$ (Mol.)</th>
<th>Energy gap $E_g$ (eV)</th>
<th>Blue shift $E_{shift}$ (eV)</th>
<th>Particle size D (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.10</td>
<td>2.75</td>
<td>1.01</td>
<td>3.852</td>
</tr>
<tr>
<td>U1</td>
<td>0.07</td>
<td>2.708</td>
<td>0.968</td>
<td>3.935</td>
</tr>
<tr>
<td>Y1</td>
<td>0.05</td>
<td>2.65</td>
<td>0.91</td>
<td>4.058</td>
</tr>
<tr>
<td>Z1</td>
<td>0.03</td>
<td>2.58</td>
<td>0.84</td>
<td>4.224</td>
</tr>
</tbody>
</table>

Fig. (4): UV-vis Absorption spectra of deposited CdSe thin films deposited at various deposition times. Fig. (5) Absorption coefficient $\alpha$ as a function of wavelength $\lambda$ for CdSe thin films deposited at different deposition time.
Fig. (6) Plot of $(\alpha h\nu)^2$ vs. $h\nu$ of CdSe thin films at different Deposition times.
Fig. (7): Variation energy gap with deposition time.

Fig. (8): Variation in particle size with deposition time.

Fig. (9): UV–vis Absorption spectra of deposited CdSe thin films at different concentration.

Fig. (10): Absorption coefficient "α" as a function of wavelength "λ" of deposited CdSe thin films at different concentration.
Fig (11): Plot of $(\alpha h \nu)^2$ vs. $h\nu$ of CdSe thin films at different concentration.
Thicknes Measurement

The thickness of CdSe thin films were measured by using weight method, as expressed by Eq. (11). The behavior of thin film thickness versus deposition time for deposition temperature baths 323, 333 and 343K are shown in figure (14). It's clear that, film thickness increases with the deposition time, but after certain minute the growing process reaches the saturation and further only lower thickness values can be achieved, also as shown in figure (14) the thickness of CdSe thin films increase as deposition temperature increase [36]. Deposition begins only when the chalcogenide concentration is high enough to allow nucleation to start, which occurs in the linear region of growth. As the limiting reactant is used up, growth will start to slow down and eventually stop due to depletion of the reactants [36]. Increase in thickness of films with temperature of deposition increase is due to increase in the kinetic energy of the ions causing more frequent collision and increased probability of CdSe formation.

Electrical resistivity dependence of CdSe thin film thickness

The electrical resistivity of prepared CdSe thin films sample (S1, S2, S3 and S4) Table (3.1) of different thickness were calculated by Eq. (10). The CBD films thickness obtained various (151, 273, 379, 452 nm). Figure (4.32) shows the electrical resistivity $\rho$ as a function of the film thickness as observed. The electrical resistivity of CdSe thin films decrease with increasing the film thickness [37].

![Graph showing the relationship between deposition temperature and thickness](image-url)
resistivity of the chemical bath depositin CdSe thin films were found in the order of $10^5 \, \Omega \cdot cm$.

![Graph](http://ijesc.org/)

Fig. (15): Plot of a room temperature resistivity $\rho$, vs. film thickness.

5.1 Conclusion:

In CBD technique, it was found that the values of pH, molarities, concentration of metal, deposition time and speed stirrer, are greatly affecting the growth of the film and it is necessary to optimize them. Thus, in order to obtain good adherence and high quality films, it is important to make balance or trade-off in preparation conditions. Different thicknesses (35-450nm) of CdSe thin films have been prepared using CBD technique. Effect of concentration has been carried out by preparing the film from a bath containing CdCl₂ with different molarities from 0.03 to 0.10 Mol. The effect of deposition time (60, 80 and 100 min) on structure properties was investigated by XRD. All prominent peaks correspond to (1 1 1), (2 2 0), and (3 1 1) planes, therefore, it has been concluded that the deposited CdSe thin films are polycrystalline in nature with cubic structure having (111) as preferred orientation. It was observed that the increase of deposition time (thickness increased) the width of diffraction peak decrease which resulted in increase in grain size. The calculated average values of grain size ranged between 6.764 and 7.479 nm, which indicates the films are nanoparticles. For effect concentration of cadmium chloride on structure properties showed an intense diffraction peaks. The prominent peaks correspond to (111), (220) and (311) planes. All the films deposited at different concentration show polycrystalline with cubic structure having (1 1 1) as preferred orientation. It was found that the average values of grain size lied between 6.462 and 7.479 nm, and decreases with concentration of CdCl₂ increase. XRD powder analyses for two concentration (0.05, and 0.07Mol.) , showed diffraction peaks correspond to (111), (220) and (311) planes which indicate that the CdSe nanoparticles are polycrystalline in nature with cubic structure, having (111) as prefer orientation. It was found as concentration increase grain sizes (4.902, 5.683 nm) increase and were found less than grain size of thin films. For effect concentration on optical properties was investigated by UV-vis spectrophotometer in the range wavelength 300-1100 nm and showed in absorption spectra with increasing concentration. A blue shift in the optical gap has been observed for the absorption spectrum of the synthesized CdSe sample, as an indication of quantum confinement effect. The absorption edge slightly shifts towards the lower wavelength with the increase in concentration. It was observed that as the concentration increase the energy gap increase. Effect of deposition time on optical properties has been observed that the absorption spectra of CBD CdSe thin films increased as deposition time was increased. A blue shift in the optical gap has been observed for the absorption spectrum of the synthesized CdSe sample, as an indication of quantum confinement effect. The absorption edge slightly shifts towards the higher wavelength with the increase in deposition time. As the deposition time increase the energy gap decrease, particle size increase. The decrease in the energy gap can be due to the influence of the various factors such as grain size, structural parameters, carrier concentration, presence of impurities, deviation from stoichiometry of the film and decrease in lattice strain. Electrical resistivity of CdSe thin films as a function of thickness was measured at room temperature, by using two point probe method. It's found that the resistivity decrease as thickness increase. The decrease of resistivity with the thickness is due to the influence of the
structural properties like grain size, lattice parameters and lattice strain. The resistivity measured in order $105 \Omega \cdot cm$.

Acknowledgements

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Reference:


[22] JCPDS Data file NO. 65-28961.


