Influence of Temperature of precursor solution on Structural and Optical Properties of Nanocrystalline CdTe thin Films Deposited by chemical bath deposition technique.

Preeti Pathak, Dr.M.Ramrakhiani, Dr. P. Mor

Abstract - Cadmium telluride (CdTe) nanocrystals were synthesized using cadmium chloride and potassium telluride as starting materials; this reaction was carried out at pH = 11.2 and refluxed at 90°C for 5 hrs. The CdTe solution "A" prepared were coated on the glass substrates by chemical bath deposition technique to obtain thin films of the CdTe with different temperature. The effect of temperature during the deposition on the structural, morphological and optical properties of CdTe thin films has been investigated. The CdTe films exhibited tetragonal structure with (111) preferential orientation. The crystallite size of the films decreased from 25.32nm to 16.90nm with the increase of temperature and the band gap of the films increased from 2.42eV to 2.59eV with the decrease of the crystallite size The CdTe thin films were characterized by X-ray diffraction and absorption spectroscopy. The absorption spectra of the CdTe thin films are shifted by 0.17eV with respect to the bulk value (1.5eV), due to the quantum size effect as expected from the nanocrystalline nature of the CdTe X-ray diffraction showed that the films consisted of small CdTe nanocrystallites of 16.90 to 25.32nm in size.

Index Terms:- CdTe thin films, chemical bath deposition, Structural properties and Optical properties, X-Ray diffraction

1. INTRODUCTION

In recent years, considerable efforts have been made to synthesize CdTe nanostructures by several methods. The chemical bath deposition (CBD) technique appears to be most suitable because of simplicity, easy to handle, cost effective and wide industrial applications.

Present work deals with preparation of CdTe nanocrystallie films on glass substrate at different temperature of precursor solution. The thin film of CdTe on glass substrate were examined for their structural, surface morphological and optical properties by means of X-ray diffraction (XRD), scanning electron microscopy (SEM), and UV spectrophotometry techniques. It was found that the size and morphology of the CdTe film were related to synthesis parameters such as the reaction temperature.The effects of temperature on the structural morphological and optical properties of the films were studied in detail.

2. EXPERIMENTAL DETAILS

CdTe nanocrystalls were synthesized using cadmium chloride and potassium telluride as starting material [0.1 M 20 ml ($CdCl_2$) + 0.1M (K_2Te)] buffer solution is used to maintain 11.2

Preeti Pathak, , Dr.M.Ramrakhiani**, Dr. P. Mor***
**Mata Gujri Mahila Mahavidyalaya, Jabalpur. (MP), India.*
***Department of Physics and Electronics*
Rani Durgawati Vishwavidyalaya, Jabalpur. (MP), India

pH, and reacting them at 90°C for 5 hrs. Water bath with reflux assembly is used for this purpose.

$CdCl_2 + K_2Te = CdTe + 2KCl$

Addition of 2-propanol produced suspension of CdTe nanocrystals named as solution A. The glass slides were cleaned with a suitable cleanser, scrubbed with soft cotton, washed thoroughly with deionized water followed by rinsing and drying in air. These glass slides were used as substrates for deposition, fixed to the circular holder dip in the solution A and allowed to rotate with a speed of 25 rpm.

The CdTe nanocrystalls formed in this manner were deposited on glass slide at different temperature of precursor solution viz 45 ^{0}C, 60°C, 90°C and for 120 min deposition time with constant stirring of the solution. Good transparent films were deposited onto glass

substrates.The transparent CdTe thin films were annealed at 200^{0}C for 2hrs.

.The crystallographic structure of the films were examined by X-ray diffractometer (XRD) (Epifluorescence Microscopy Model, Rigaku, Nikon, Japan) using the monochromatic CuKα radiation (1.5406Å).The surface morphology and elemental composition analysis of the films were studied using High Resolution scanning electronmicroscope (FESEM-SUPRA 55 - CARL ZEISS, Germany). The optical spectra of the films were recorded using UV-Vis absorption double beam spectrophotometer (Perkin Elimer, Lambda-12 spectrophotometer) in the nm wavelength range.

3. Results and discussion:

(a) Thickness studies

The thickness of the CdTe film was measured with the help of weight difference method or gravimetric method, employing sensitive electronic microbalance using bulk density of CdTe (6.02gm/cm^3).

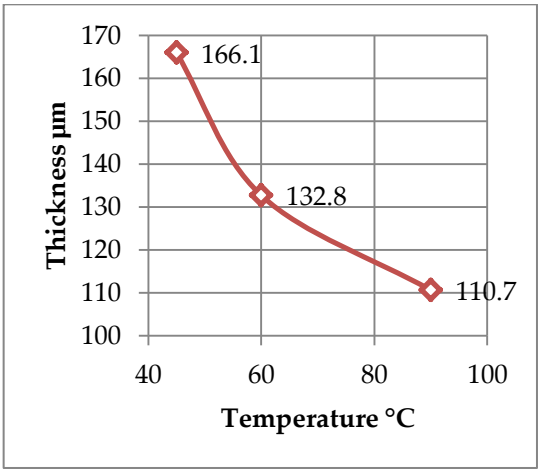

Fig. 1 Thickness of the films as a function of temperature of precursor solution.

Fig 1 shows the graph of thickness of the film for various temperature of precursor solution. The thickness of the deposited Cadmium Telluride thin film decreases when the deposition is done at higher temperature. The decrease in thickness with temperature of precursor solution could be due to the change in crystallite size and particle size accompanied with temperature of precursor solution.

[b] XRD studies

In order to determine the size and to study the structural properties of the synthesized CdTe thin films, the XRD analysis was performed. The phenomenon of X-ray diffraction can be pictured as a reflection of the incident beam from the lattice plane

The average crystal size of CdTe samples were calculated by using the Scherer's formula

$D = 0{\cdot}9\lambda / \beta\cos\theta$ ---------- (1)

Where:

D = Average crystallite size

λ = X-ray wavelength (1·542 Å)

β = FWHM of the peak

θ = Bragg angle.

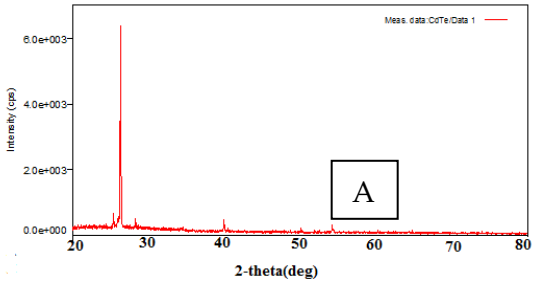

Fig 2[A]

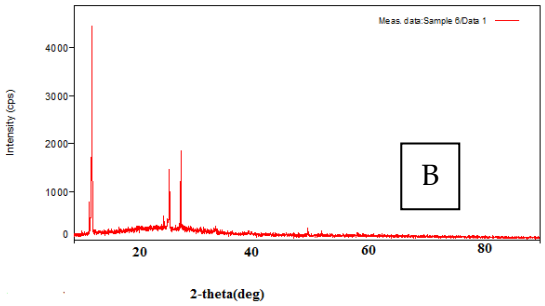

Fig 2[B]

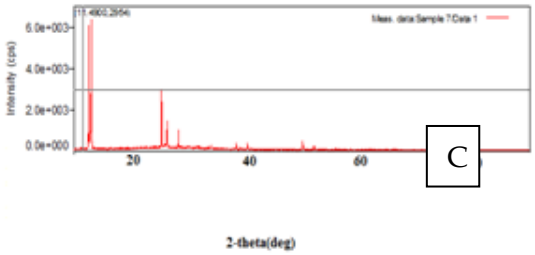

Fig 2 [C]

Fig 2 [A],[B],[C] show X-ray diffraction pattern of deposited CdTe thin film deposited at 45°C 60°C 90°C Temperature of precursor solution.

The structural identification of CdTe films was carried out with X-ray diffraction in the range of angle 2θ between 10º to 80º. The XRD patterns for CdTe thin films are nanocrystalline in nature. The well defined **(111), (220), (200) (222) (311) (400) (331) (333) (420) (440)** (**110**), (**101**), and (**210**) peaks were observed in the XRD patterns due to CdTe crystals. The strong and sharp diffraction peaks indicate the formation of well crystallized sample. It can be seen that the major peak (111) is strongly dominating the other peaks. From the full-width at half-maximum of the diffraction peaks, the average sizes of the nanocrystallites have been calculated by Debye-Scherrer formula for various deposition times and given in table 1. The structure of CdTe deposited is predominantly tetragonal and reasonably crystalline. PDF card number 9007154 is used for comparing the standard values with the experimental data. It is observed that the calculated average grain size for deposited CdTe thin film decreases with increase in temperature of precursor solution.

Table 1.Effect of temperature of precursor solution on Particle Size

S.No.	Temperature of precursor solution	Particle Size
1	45°C	25.32nm
2	60°C	20.25nm
3	90°C	16.90nm

[c]. SEM studies

Surface morphology and topography of nanoparticles of CdTe deposited thin film were investigated using SEM images.

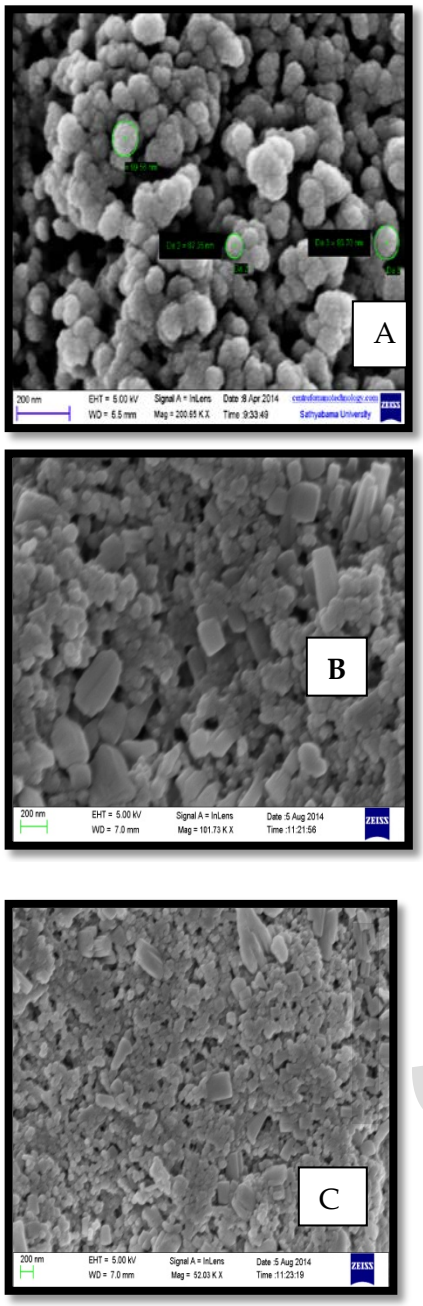

Fig 3 [A] [B] [C] SEM images of CdTe thin film deposited on glass substrate for temperature of precursor solution are 45°C, 60°C, 90°C.

The micrograph [A], [B], [C] shows that the substrate is well covered with a large number of densely packed well oriented fine grained surface particles. The SEM pictures show the deposited CdTe to be of large grain size, uniform coverage and low porosity. At the optimized concentration, well covered, uniform, rounded, densely packed grains on the surface are observed. Figure shows that as temperature of precursor solution is increased the crystallite size decreases.

[d]. Optical absorption-spectroscopy

The optical absorption of the films was measured using UV-visible spectrophotometer at room temperature. (UV) spectroscopy is a technique used to quantify the light that is absorbed and scattered by a sample.

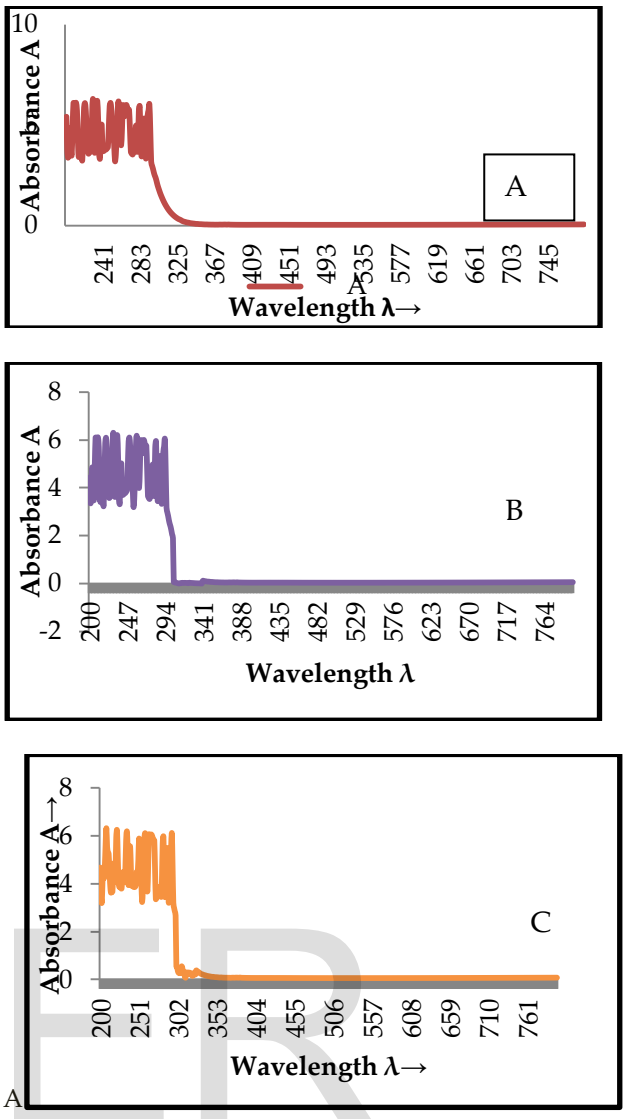

Fig.4 [A][B][C] shows the Optical absorption spectra of thin films of the CdTe synthesized at temperature of precursor solution are 45°C, 60°C, 90°C.

It is observed that there is red shift in absorption edge or first absorption peak indicating increase in effective band gap. Effective band gap was computed using formula Eg=1240/ λ (at absorption edge).

Table2: Effect of temperature of precursor solution on bandgap and particle size

Temperature	Absorption Edge	E_{Nano}	ΔE shift in Band gap	Particle size in nm
45^{0}C	313	3.96	2.42	24.59
60^{0}C	305	4.06	2.52	24.07
90^{0}C	300	4.13	2.59	23.76

The value of optical band gap (Eg) changes with decrease in thickness from 166.1 to 110.7μm.From table it is observed that the calculated value of particle size (r) for deposited CdTe thin film decreases slightly with increase in temperature of precursor solution. it is clear that the absorption edge of the films moved towards the lower wavelengths with increase in substrate temperature since ΔE i.e. shift in band gap of

deposited cadmium telluride increases with increase in temperature of precursor solution. The actual band gap of the CdTe (bulk) is 1.45eV.

4. CONCLUSION

Nanocrystalline CdTe thin films at different temperatures of precursor solution are deposited by chemical bath deposition technique. The effect of temperature of precursor solution on the structure, morphology and optical properties of the CdTe films is investigated. The structure of the CdTe thin films is Tetragonal structure with a preferential orientation of (111) plane. Morphological studies revealed that decrease in the crystallite size with the increase in temperature of precursor solution from 45°C to 90°C. The band gap of the CdTe thin films slightly increased and particle size decrease with increase in temperature of precursor solution .This increase in band gap may be attributed to the decrease in particle size with corresponding increase in temperature of precursor solution.

5. Acknowledgement

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