The Structural, Optical and Electrical Properties of CdTe Thin Films

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Abstract:- **Cadmium Telluride (CdTe) thin films were developed on glass substrates by wet chemical process. The post annealing effect of CdTe thin film has been studied for the prepared films that are annealed at different temperatures. The structural, optical and electrical properties had been characterized for the films. XRD study had been done for the structural characterization. All the films had a well defined crystal structure. The morphological studies were analyzed using Scanning Electron Microscopy (SEM) studies. The energy band gaps of the films were analyzed by photoluminescence (PL) study. I-V characterization and conductivity of the films were analyzed using four probe study.**

Keywords: CdTe, XRD, SEM, PL, I-V

I. INTRODUCTION

In these recent years, thin films have attracted much interest because of their applications such as semiconductor devices, photovoltaic, optoelectronic devices, laser materials, infrared detectors, solar energy converters, etc.,. A lot of literature is available for the preparation and characterization of thin film materials [1-3]. CdTe is one of the promising materials because of its high absorption coefficient and the nearly optimum band gap for the efficient absorption of solar radiation. In the conventional solar cells, the CdTe was used as the absorber layer. In previous work, CdTe thin films were grown onto very thin stainless steel, nickel and molybdenum substrates etc.,. To our knowledge, the preparation, nucleation and growth of the CdTe onto different substrate can be found in the literatures. Various growth techniques, such as molecular-beam epitaxy, metal organic chemical vapor deposition, UHV sublimation hot wall epitaxy, thermal evaporation, sputtering, spin coating, spray, and chemical bath deposition have been used to grow CdTe thin films [4-10]. Reports about the effect of the post deposition heat treatment on the structural changes of CdTe thin films and its influence on the performance of CdTe based solar cells are also available. Fabrication of crystalline thin films is essential in order to improve quality, lower production costs, and easy coating method. Dip coating is an alternative technique that has been successfully used for thin film preparation.

In the current work, the studies of wet chemical dip coating of CdTe onto glass substrate and the effect of annealing temperature are present.

II. EXPERIMENTAL PROCESS

2.1 Substrate Cleaning

Transparent Microscopic glass slides were used as substrates. The glass substrates were washed with soap solution, rinsed with deionized water. The glass plates were soaked in hot chromic acid at 90˚C for 15 minutes and again washed with deionised water and kept in an ultrasonic water bath for 15 minutes and then the wiped with acetone and finally dried at 100˚C.

2.2 Preparation of CdTe thin film

The wet chemical dip coating method is used for the preparation of CdTe thin films on glass substrates. In the film forming process requisite amount of $Cd(CHOOH)_2.4H_2O$ and Te salts was dissolved into ethanol and H_2SO_4 respectively to make two separate solutions. After preparing two solutions they are mix-up each other with the help of magnetic stirrer for 7 hours to get the parent solution (CdTe solution) for the deposition of the thin film. The prepared glass substrates were dipped into the prepared solution and then withdrawn vertically at a controlled speed, under atmospheric condition, with the help of a dip coating machine, when a liquid film adhered to the substrate. The prepared films were annealed at 300ºC, 350ºC and 400ºC temperatures.

The results of X-ray diffraction, Scanning Electron Microscopy, photoluminescence and electrical study of the prepared thin films were discussed.

2.3 Characterization Details

The thin films structure was investigated using X-pert PRO X-ray diffraction with CuKα radiation having wavelength 1.5418Å. The SEM images were taken using Hitachi S–3000N scanning electron microscope with an accelerating voltage of the electron beam of 30 kV. Photoluminescence study was carried out using a Shimadzu RF-5301PC apparatus with a xenon lamp as light source and the electrical characterization were done by four probe method respectively.

III. RESULT AND DISCUSSION

3.1. X-Ray Diffraction (XRD)

The XRD characterization of prepared CdTe thin films with the annealing temperatures (300ºC, 350ºC and 400ºC) was shown in fig.1. The films were exhibited the polycrystalline nature. The 2θ value of the films were 23.8, 39.4, 46.3 and 67.34, the corresponding h k l values are (111) (220) (311) and (204) orientation. These values are good agreement with JCPDS file no. 80-0090 [11-13].

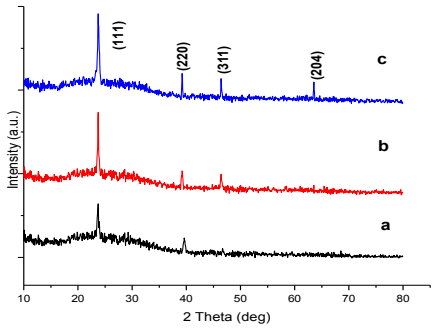

Fig.1 shows the XRD pattern of CdTe thin films annealed at different annealing temperatures ((a) 300ºC, (b) 350ºC and (c) 400ºC)

The annealing temperature increases the crystallinity of the films. The grain size, strain, dislocation density and yield strength were changed with increasing of annealing temperature. It is may be affect the mechanical, optical and electrical properties of the films.

3.2. Scanning Electron Microscopy (SEM)

The surface morphology of the prepared CdTe thin films was shown in figure. The 300ºC film was amorphous in nature with a non uniform size of CdTe particles. This is no grain boundaries are present in the films. Thereafter increasing of annealing temperatures 350ºC and 400ºC the crystallinity of the

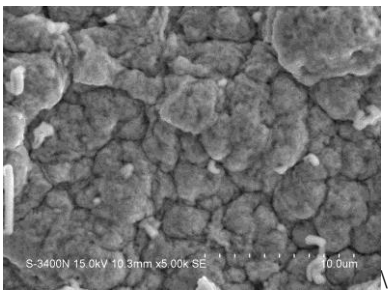

Fig. 2 (a)

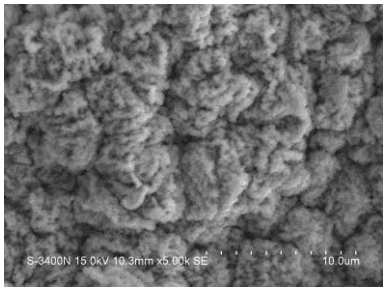

Fig. 2 (b)

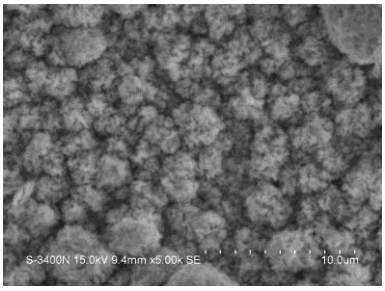

Fig. 2 (c)

Fig.2 shows the SEM image of CdTe thin films annealed at different temperatures ((a) 300ºC, (b) 350ºC and (c) 400ºC))

CdTe films were improved and the grain boundaries are created. The particles distributed on the entire surface of the substrate it shown in fig.2.

3.3. photoluminescence (PL)

The photoluminescence of prepared CdTe thin films are shown in fig.3.The excitation wavelength was 395 nm, the emission spectra of the films were 690 nm and 729 nm. The energy band gap of the prepared CdTe films exhibits ~ 1.8 eV. The peak intensity was increased with increasing annealing temperature [13]. The red shift was present in the films.

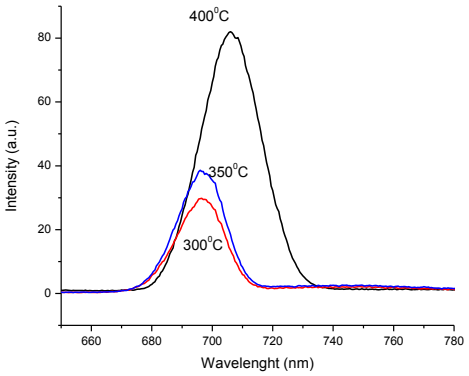

Fig.3 shows the photoluminescence (PL) study of of CdTe thin films annealed at different annealing temperatures (300ºC, 350ºC and 400ºC).

3.4. Electrical studies

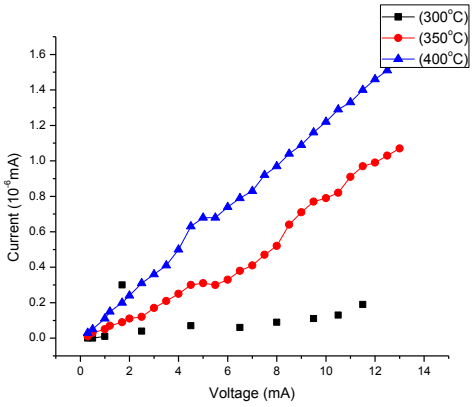

Fig. 4 (a) shows the V-I curve of CdTe thin films under dark condition.

The Current – voltage characterization of the CdTe thin films prepared at different annealing temperature are shown in fig.4. The voltage increases the current also increased with increasing of annealing temperature. The films deposited at 350°C and 400°C temperatures were slightly higher current than the film prepared at 300°C and it's due to the better crystallinity of the CdTe thin film.

The I-V is measured using a dark condition and under light illumination for the films deposited at different annealing temperature as shown in fig. 4(b). It was clearly shown that the CdTe films have photoconductive character [14]. The photocurrent not so high compare with dark current.

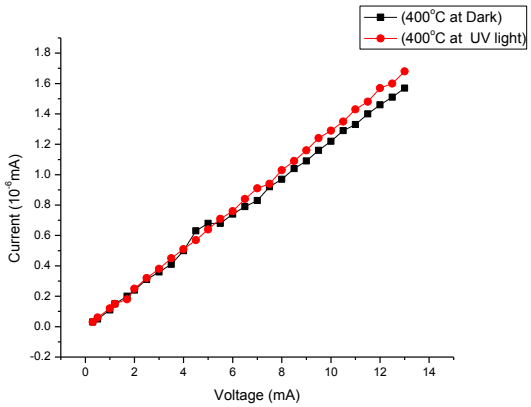

Fig. 4(b) shows the dark and UV light illumination of 400°C annealed CdTe thin films.

IV. CONCLUSION

CdTe films were prepared by cost effective dip coating technique. Films were grown under atmospheric pressure at different annealing temperatures. XRD analysis of the films confirms the formation of cubic structure and predominately (111) orientation films. The SEM studies exhibits the morphological structure. From the PL studies the energy band gaps of prepared thin films were analyzed using PL characterization. The energy bands of the films were ~ 1.8 eV with red emission. photocurrent response that could be used for photovoltaic devices.

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