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Studies on growth kinetics of $CdIn_2Te_4$ thin films

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ABSTRACT

Thin film deposition processes play a critical role in the production of high-density, high-performance microelectronic products. Considerable progress has been achieved in the development of deposition processes and in the development of the reactor systems in which they are carried out. In recent year, thin film have attracted more because of their varied applications such as semi conducting devices[1-2], photovoltaic, optoelectronic device, radiation detector, laser materials, thermoelectric devices, solar energy converter.etc. [1-4]. Ultra thin films are two- dimensional micro material, which are obtained by DC electro deposition technique[4] on surface of stainless steel from an aqueous acidic bath containing $CdSO_4$, $InCl_3$ TeO_2. The growth kinetics was studies by knowing effect of pH of electrolyte bath, optimizing time of deposition. An effect of bath pH is studied by measuring I_{SC} and V_{oc}. Effectiveness of current – voltage characteristic was studied by plotting values of I vs V. X-ray diffraction analysis of the deposited film showed the presence of polycrystalline nature with tetrahedral structure with lattice parameter a = 6.205, b=6.205, c =12.405. From X-ray diffraction (XRD) analysis interplanner distance, particle sizes have been calculated. Surface morphology studies by scanning electron microscope (SEM) shows that, the deposition films are well adherent and grains with grain size 0.22 μm^2 and particle size 1.4671A^0 are uniformly distribution over the surface entire of the substrate

Key words: Thin film, Electro deposition, crystal structure, XRD; SEM

INTRODUCTION

Then solid film were probably first obtained by electrolysis in 1838 . However Bunseb and grove obtained metal thin films in 1852 by mean of chemical reaction and by glow discharge sputtering respectively faraday obtained metal film in 1957 by thermal evaporation on explosion of a current carrying metal wire. The usefulness of optical properties of metal film, and the specific curiosity about the behavior of two dimensional solid have been responsible for the major interest in the study of science and the technology of thin film . The varied and irresponsible results often obtained on the films led most workers to conclude that the vapour deposited film represented a high state of disorder and that no two films are alike.

The technology and understanding of films less than 1 micron thick have made tremendous advantages in last decade, primarily because of industrial demand for reliable thin film microelectronic device to fulfill the urgent needs of sputteric era. This progress has brought maturity and much scientific confidence in a use of thin film for basic and applied research. In addition to major contribution to a variety of new and future scientifically based technologies, thin film studies have directly or indirectly advance may new area of research in the solid-state physics and chemistry, which are based on phenomenon quickly characteristic of thickness, geometry, and structure of film.

Thin film technology

Magnitudes of techniques have been developed to prepare poly crystalline and nearly single crystal film of all types material. Deposition rates may range from fraction of angstrom per second. Among these deposition techniques, those of thermal evaporation by resistive and electron bombardment heating, sputtering by mean of glow discharge, rf and ion beams and the vapour deposition by variety of chemical reaction have been perfected.

Some of the laboratory depositions techniques have been carried over to the production stage in new industry notable example of successful industrial processes are the use of thermal evaporation of Al for aluminization of foils, inert and reactive sputtering of Ta for thin film microminiaturized resistor and capacitors with component densities exceeding 10^4 / cm^2 and chemical deposition of Nb_3Sn on foils for the winding of super conducting magnets.

Structure and growth

The unique growth stages of vapour-deposited films consist of statistical process nucleation of the vapour atoms, surface diffusion controlled growth of the three dimensional nuclei, and formation of a networked structure and its subsequent feeling .The most characteristic stage is that of a liquid like coalescence of nuclei to form the network structure . This plays dominant role in the microstructure and epitaxial growth of films, and the introduction and annihilation of structural defects. Studies of this film growth stage provide an insight in to the basic crystal growth process.
The deposition parameter may be exploited to influence the kinetics of film- growth stages and there by obtain films with structures ranging from a completely disordered (amorphous) to a highly ordered (monocrystalline) form. Further one can prepared film with an automatically smooth surface, or rough film with an effective surface area hundreds of times larger than the geometrical area.

MATERIAL AND METHODS

$CdIn_2Te_4$ thin films were deposited by the DC electro deposition technique on stainless steel of surface area 1×1.5cm^2 from an aqueous acidic bath containing $CdSO_4$, $InCl_3$ TeO2 as a precursor. Chemicals required for preparation of acidic bath of electrolyte were as follows

1. AR grade $CdSO_4$
2. AR grade $InCl_3$
3. AR grade TeO_2
4. AR grade H_2SO_4

Preparation of bath

Bath of electrolyte was prepared by taking clear solution of $CdSO_4$, $InCl_3$ TeO_2, 5ml, 10ml, and 20ml respectively. Maintained the P^H of bath at acidic range.

Electro deposition

The substrate of stainless steel were mirror polished by zero polish paper & clean with chromic acid finally washed in a ultrasonic bath. The economical inert & polished graphite plate was use as a counter electrode. The deposition potential were measured with respect to saturated calomel electrode by keeping pH constant deposition time for the film was optimized. Graphically it is shown in fig. 1

Then by keeping the optimized time constant proper pH for the film was optimized confirmation is done by measuring Isc and Voc. After taking I_{SC} and V_{oc} optimization was confirmed. Structural analysis of film has been done by XRD & SEM

The PEC was fabricated by using CdIn2Te4 thin film as a active photo electrode, polysulphide (0.1M NaOH + 0.1M Na_2S + 0.! M S) solution as the electrolyte and graphite as counter electrode for the I_{SC} V_{OC} and IV characteristic calculations. The photo electrode was illuminated with a 500mw tungsten filament lamp.

RESULTS AND DISCUSSION

The polarization curve was plotted to determine the deposition potential of $CdIn_2Te_4$ thin film from its baths, shown in fig.2

Concentration of $CdSO_4$, $InCl_3$ and TeO_2 is 0.1M respectively. The film was deposited at the optimized potential at 1700 mV Vs SCE and at current density 0.2 mA/cm^2, deposited film have

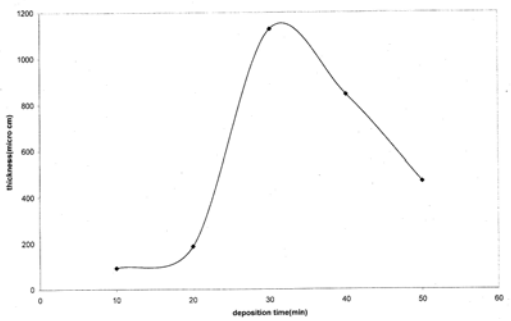
Table 1: 'd' value comparison

(hkl) planes	Lattice constant A	Lattice constant C	Standard 'd' value	Observed 'd' value
112	6.205	12.405	3.5819	3.5819
220	6.205	12.405	2.1938	2.1938
312	6.205	12.405	1.872	1.874

Table 2 : Particle size

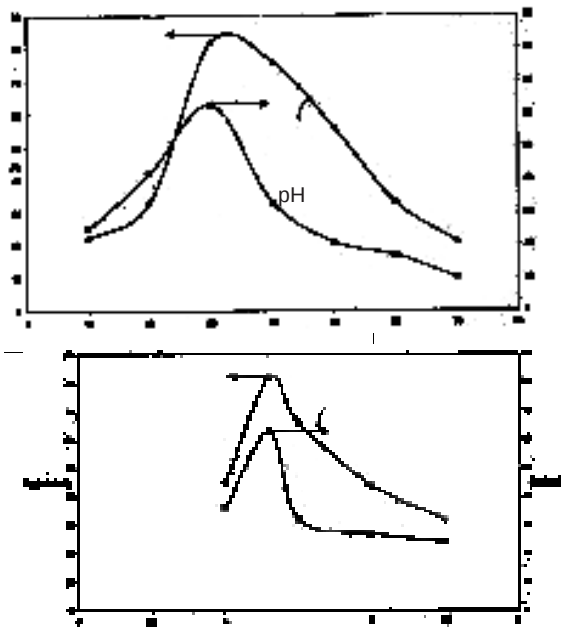
2θ	θ	β	Particle size
24.835	12.835	0.97	1.4671A^0

been dried and preserved for further studies on various pH films have been deposited for 10, 20, 30 40, 50 minutes respectively in order to deposition time and pH of bath. Variations in Isc Voc are the function of deposition time and pH of the electrolyte It is observed that the Isc and Voc values are relatively higher at bath pH 1.3 and 30 minutes



deposition time (min)

Fig. 1



deposition time (min) pH

Fig. 3: Effect of deposition time on ISC and VOC

Fig. 4: Effect of pH on ISC and VOC

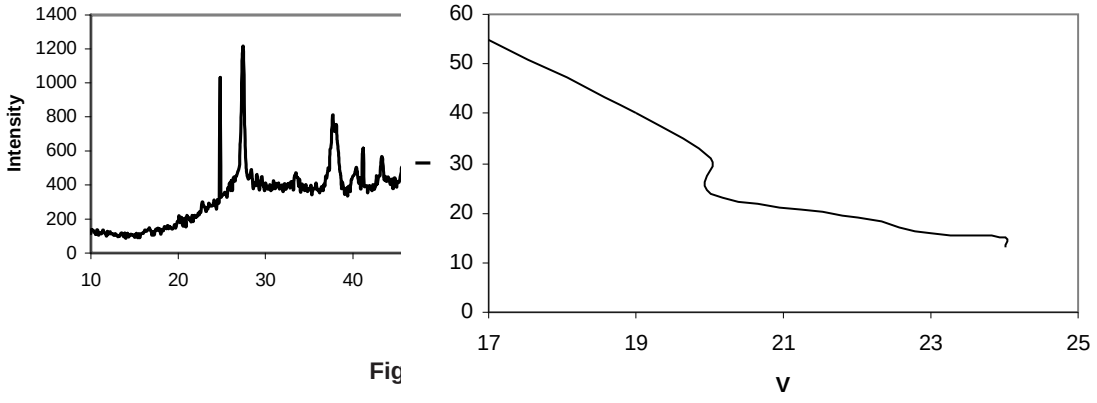
deposition time. This may due to formation of nearly stichiometric $CdIn_2Te_4$ thin film material Fig -3 and 4 shows the effect of pH on Isc and Voc.

By the calculations of Isc, Voc, Im & Vm graphs shown in fig. 5 , efficiency of thin film found to be 9.00

Further the XRD analysis of the thin of $CdIn_2Te_4$ on stainless steel substrate shown in the fig-6.

The XRD analysis of the thin film of $CdIn_2Te_4$. reveals that thin film is polycrystalline, and sharp peaks are observed at (112), (204), (220),

Fig. 5: IV- Characteristic



Fig

Fig. 7

Fig. 8

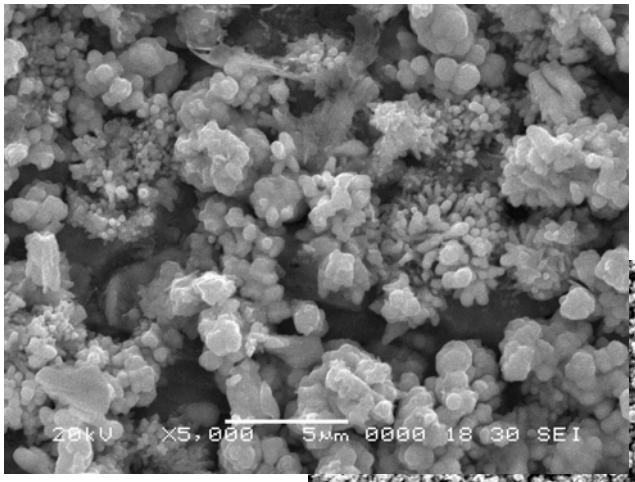


Fig. 9

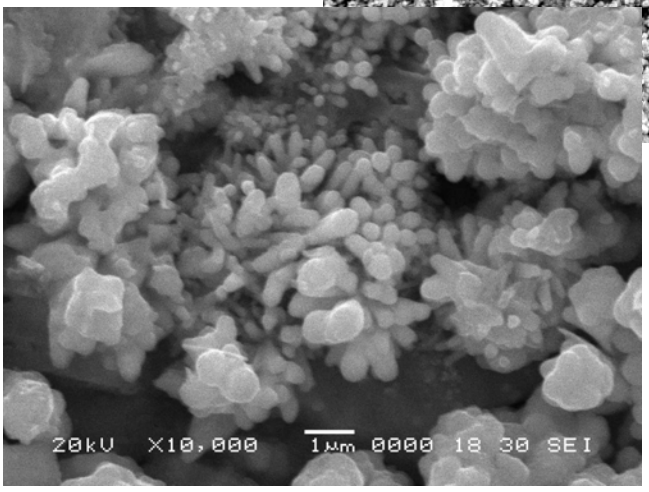


Fig. 10

(312) planes of $CdIn_2Te_4$ crystal. Observed 'd' values with standard are given in table no. 1 also confirm the formation of $CdIn_2Te_4$ material. It again confirmed by matching of observed particle size and standard particle size of $CdIn_2Te_4$. Graphical representation shown by Fig. 7

Following tables are showing comparative data of 'd' value, and size of particles of $CdIn_2Te_4$ crystal formed.

CONCLUSION

Almost stichiometric $CdIn_2Te_4$ thin films formation by electro deposition technique were taken from acidic bath. The film grown at the optimized pH and time is polycrystalline with tetrahedral structure and the particle size found to be1.4671A^o, lattice parameter a= 6.205, b= 6.205, c =12.405 and grain size found to be 0.22 mm^2. SEM analysis shown by Fig. 8,9,10.

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