CR-DOPED PBS THIN FILMS GROWN BY CHEMICAL BATH DEPOSITION IN DEVELOPING HD- D DOPED CHARACTERISTICS

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Abstract

Chemical bath deposition will used to create nanocrystalline undoped and Cr-doped PbS thin films on glass substrates, respectively. Polycrystalline films with cubic structure were found by X-ray diffraction to grow preferentially in the (111) direction. PbS crystallite size decreased from 59.97 nm to 37.59 nm with Cr inclusion, whereas strain and dislocation density increased. There are three different doping levels for Cr based on the EDX spectrum, with a ratio of 0.63, 1.75, and 4.70 percent. The average size of nanoclusters reduced from 73 nm to 41 nm as the Cr content rose, according to morphological examination. As the amount of Cr doped is raised, so are the optical band gap values. Photoelectrochemical (PEC) reactions and the photoelectrodes' stability were examined in 0.3 M Na2SO3 electrolyte solution. In addition, the incident and applied bias photon-to-current efficiencies were computed and exhibited optimum values of 13.5 percent and 1.44 percent at 0.68 V and 390 nm, respectively. Besides that, the improved electrode has a long life span and a high chemical stability. Finally, the effect of temperature on PEC behaviour is investigated and thermodynamic parameters are derived.

Keywords: *Copper sulphide, CBD, XRD, SEM, Dielectric constant and Dielectric loss*

1. Introduction

Nanomaterials have been extensively discussed due to their unique physical and chemical properties and also its potential applications in diverse areas [1]. These properties and potential applications have motivated the search for novel synthetic methods for these materials. In current years, huge resources were devoted to the preparation of nanocrystals using a broad variety of methods including electrodeposition [2], solvothermal route [3, 4], thermal decomposition [5] and chemical reduction [6]. These efforts have led to the successful synthesis of various nanocrystals including metals [7, 8] oxides [9], as well as sulfides [10, 11] which have previously been used as optoelectronic materials in sensors, laser materials, solar cells and other devices. Metal chalcogenide thin films discover the applications in superconducting films, diamond films, magnetic films, microelectronic devices, surface modification, hard coatings, photoconductors, IR detectors, solar control, solar selective coatings, optical imaging, solar cells, optical mass memories, sensors, fabrication of large area photodiode arrays catalyst etc[12-15]. In the present paper deals that the structural and electrical properties of CuS thin films. The CuS thin films subjected to study are characterized by X-ray diffraction, scanning electron microscopy (SEM) and dielectricstudies.

2. Material and methods

Chemical bath deposition in current period of time is been widely used for synthesizing thin film because of the advantages of this method like it is cheap method, occur at easily reasonable temperature, simple and convenient for large scale deposition etc. The copper sulphide thin films have been prepared from an acidic bath using aqueous solutions of copper sulphate and thiourea. The tartaric acid has been used as complexing agent for the period of the deposition process. The microscope glass slides have been used as the substrate for the chemical bath deposition of CuS thin film. Before deposition, the glass substrates have been degreased with ethanol for 10 min. Then, ultrasonically cleaned with distilled water for another 10 min and dried in desiccators. Deposition of CuS thin films were done at 80 °C by using following procedure: 25 mL of copper sulphate was complexed with 25 mL of tartaric acid in beaker. Then, 25 mL of thiourea was mixed in it with constantstirring. The pH was adjusted to 3 by addition of hydrochloric acid with constant stirring using pH meter. The cleaned glass substrate was immersed vertically into beaker. The deposition process was carried out in order to determine the optimum conditions for the deposition of CuS thin films. After the completion of deposition, the films were washed with distilled water and kept for analysis.

3. Results and Discussion

3.1 Structural Properties

The X-ray diffraction patterns (XRD) are examined to find the structural information of thin film. The structural analysis of CuS thin film has been done by using X-ray diffractometer in the range of scanning angle 20–60°. The X-ray diffraction patterns of the CuS thin films are shown in Fig.1. The planes (100), (102), (103), (006), (110) and (108) show the covellite phase with hexagonal crystal structure for CuS thin film.

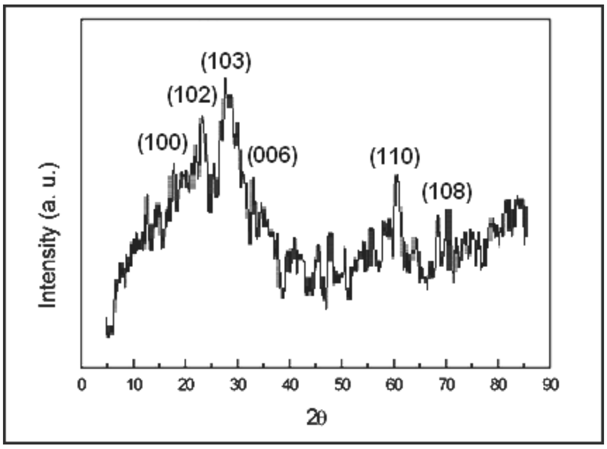


Fig.1 XRD pattern of CuS thin films

3.2 Surface Morphology of the Thin Film

SEM is a shows potential technique for the morphology of thin films. It gives as significant information regarding growth, shape and size of the particles. In the present CuS thin films, the copper precursor solution prepared for the development of thin film by Chemical bath deposition method, as reported elsewhere [16]. SEM images of CuS thin films are shown in Fig.2. It is seen that well-crystallized grains in the image belong to these films. From the image of CuS thin films, it is clearly seen that the particles forming the films are in nanoscale.

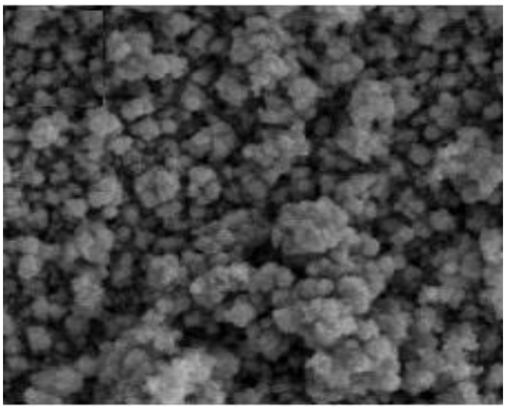
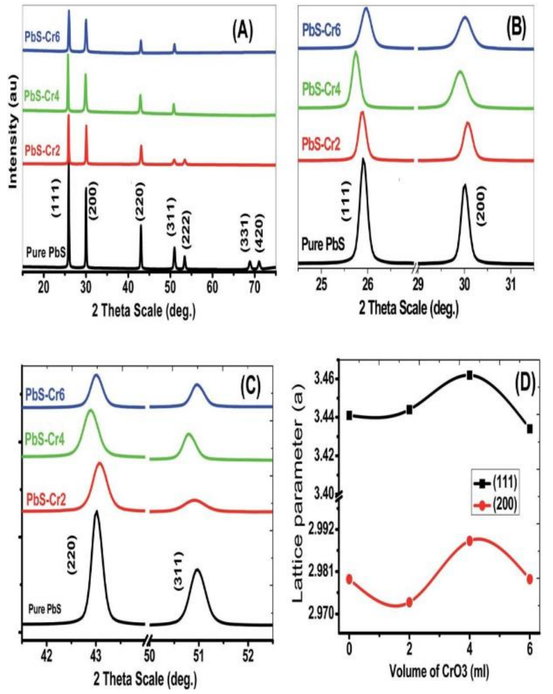


Fig.2 SEM image of CuS thin film

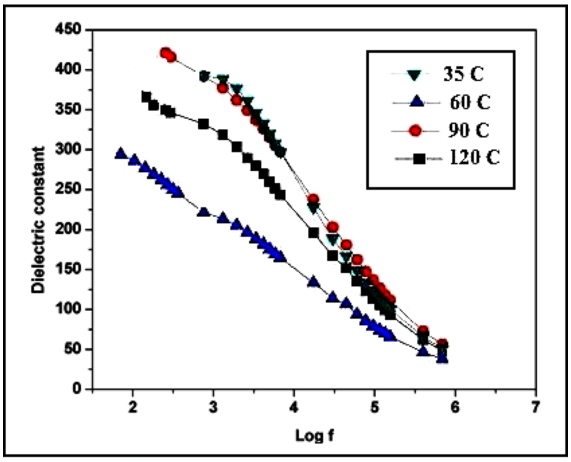
XRD study and EDX analysis

The crystal structure of the pure and Cr-doped PbS thin □lms deposited on glass by the CBD was studied by XRD to identify the phases present. Fig. 1 shows the XRD patterns of pure and doped PbS □lms. According to standard cards # 04-002-0034 and 00-005-0592, all the observed diffraction peaks have single- phase agreed with the standard diffraction patterns of face



(A–C) XRD spectra for nanostructure pure and doped PbS thin films with different Cr content. (D) The lattice parameter for (111) and (200) planes.

The dielectric loss calculated as a function of frequency at different temperatures is shown in Fig. 4. These curves suggest that the dielectric loss is strongly dependent on the frequency of the applied field, similar to that of the dielectric constant. The dielectric loss decreases with an increase in the frequency at almost all temperatures, but appears to achieve saturation in the higher frequency range at all the temperatures. In the low frequency region, high energy loss is observed, which may be due to the dielectric polarization, space-charge and movement of electrons in rotational manner at low frequency range.



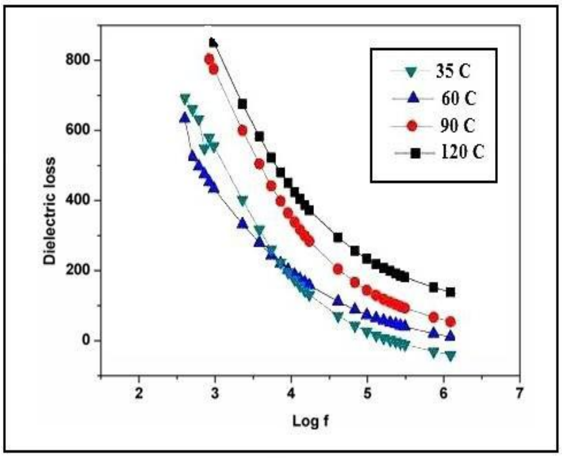


Fig. 4. Dielectric loss of CuS thin films, as a function of frequency

The texture coefficient (TC) was evaluated to quantify the preferred crystallographic orientations of the samples. It is observed from Table 1 that the plane (111) has a high texture coefficient, indicating that the nanocrystals have preferential coordination towards the (111). In many previous works, the (200) preferential growth is observed for PbS thin films.[34,38] The variation of preferred orientation can be explained from the thermodynamic point of view. Xigui*et al.* have proposed that the reason for this variation is the change of the total system free energy during the □lm growth which is affected by the surface, interface and strain energy contributions. Moreover, the degree of these three energies contributions may be different under certain preparation conditions, which consequently leads to different preferred orientations.

Table 1: Electronic parameters of the CoS thin films

Parameter	Value
Plasma energy ($\hbar\omega_p$)	19.93 eV
Penn gap (E_p)	1.55 eV
Fermi Energy (E_F)	15.77 eV
Electronic polarizability (using the Penn analysis)	4.72×10^{-24} cm^3
Electronic polarizability (using the Clausius-Mossotti relation)	4.84×10^{-24} cm^3
Electronic polarizability (using bandgap)	4.55×10^{-24} cm^3

Conclusion

The Copper sulphide (CuS) thin films were prepared by chemical bath deposition technique. Structural properties of CuS thin films were investigated by XRD and SEM methods. The X-ray diffraction (XRD) and scanning electron microscopy is used to establish the structure and crystallite size of these films and also to study the particle size and morphology. The dielectric constant and dielectric loss of the CuS thin films are calculated in the frequency range of 50Hz-5MHz at different temperatures. The dielectric studies reveal that both the dielectric constant and dielectric loss decrease with an increase in frequency. The dielectric characterization shows the low value of the dielectric constant at higher frequencies

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