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Structural and Electrical Properties of Copper sulphide Thin Films by Chemical Bath Deposition Method

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Abstract: Copper sulphide (CuS) thin films were synthesized by chemical bath deposition method. The X-ray diffraction (XRD) is used to establish the structure and crystallite size of these films and scanning electron microscopy is used to analyze the particle size and morphology. The dielectric properties of CuS thin films were studied in the different frequency range of 50Hz-5MHz at different temperatures. The frequency dependence of the dielectric constant and dielectric loss is found to decrease with increase in frequency at different temperatures.
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 dielectric studies.

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 degrased 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 constant

stirring. 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.
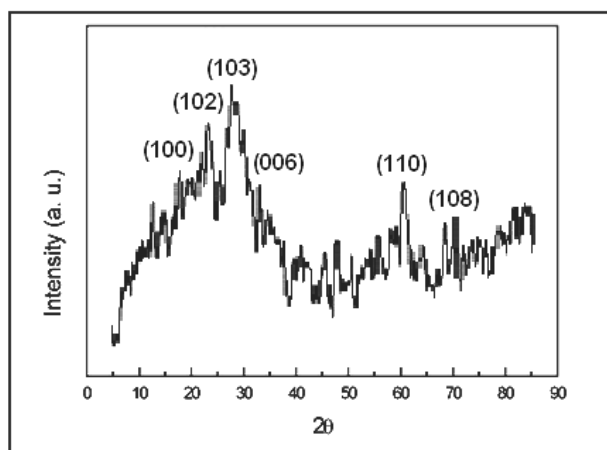

Fig.1 XRD pattern of CuS thin films

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.
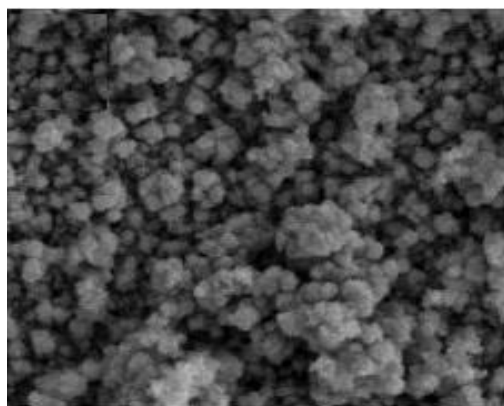

Fig.2 SEM image of CuS thin film

3.3. Dielectric properties

The dielectric constant and the dielectric loss of the CuS thin films were calculated at different temperatures using the HIOKI 3532 LCR HITESTER instrument in the frequency region of 50 Hz to 5 MHz. The dielectric constant has been measured as a function of the frequency at different temperatures as shown in Fig.3, while the consequent dielectric losses are depicted in Fig. 4. Fig. 3 shows the plot of the dielectric

constant versus applied frequency. It is observed (Fig.3) that the dielectric constant decreases exponentially with increasing frequency and then attains almost a constant value in the high frequency region. This also shows that the value of the dielectric constant increases with an increase in the temperatures. The net polarization present in the material is due to ionic, electronic, dipolar and space charge polarizations [17]. The large value of the dielectric constant is due to the fact that CuS thin films acts as a nanodipole under electric fields. The small-sized particles require a large number of particles per unit volume, resulting in an increase of the dipole moment per unit volume, and a high dielectric constant.

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.
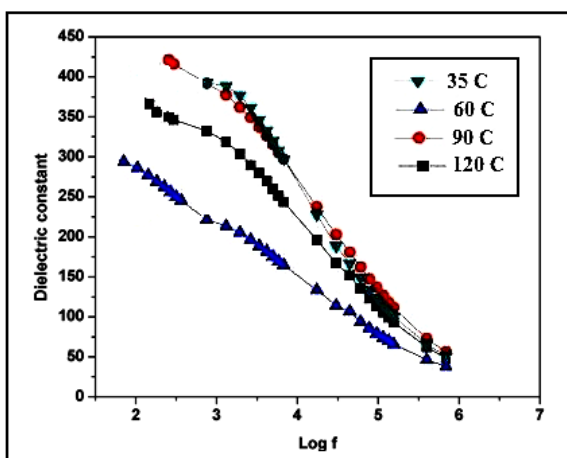

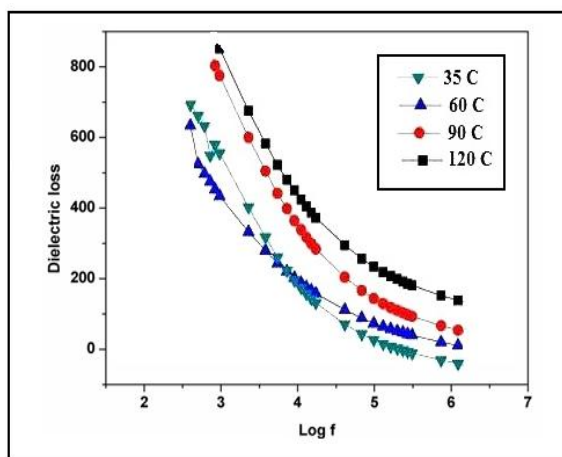**Fig. 3. Dielectric constant of CuS thin films, as a function of frequency**

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

4. 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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