

Physical and Optical Properties of Chemically Deposited Copper Selenide (CuSe) Thin Films at Room Temperature

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ABSTRACT: Nanostructured Copper Selenide thin films have been grown onto glass substrate by using chemical bath deposition method at 353K. The films were characterized by using X-ray diffraction technique (XRD), scanning electron microscopy (SEM) and optical measurement techniques. The structural studies indicates that CuSe thin films are nanocrystalline in nature with a hexagonal structure having preferred orientation along (102) plane. Morphological studies reveal that the grains are well defined, spherical, of almost similar sizes, which were almost uniformly distributed over a smooth homogeneous surface. Optical properties of the copper selenide thin films were studied using Lambda 25 UV-VIS spectrophotometer (PerkinElmer) in the spectral range 200 -1200 nm. The optical band gap of the deposited film was found to be 2.48eV.

KEYWORDS: Thin films; Nanostructures; Chemical Bath Deposition; Optical properties.

1. INTRODUCTION

Intensive research has been achieved in the past to study the fabrication and characterization of copper selenide in the form of thin films because of its potential application in solar cell technology. Copper selenide is a semiconductor with a wide range of stoichiometric compositions and also with various crystallographic forms. Recently, the techniques of thin film growth of this compound has become of interest in fabricating low cost photocells. CuSe thin films have been prepared by many researchers using various techniques such as chemical bath deposition [1], vacuum evaporation [2] and solution growth technique [3] etc. Copper selenide is an interesting direct band gap p-type semiconductor material with band gap value of 2.15eV to 2.3eV, which makes it a promising materials for solar cell conversion [4-6], photo-detectors and electro-conductive electrodes [7]. Copper selenide thin films are mostly found to crystallize in hexagonal structure. Although the properties of copper selenide thin films depends on the deposition processes and deposition parameters, each deposition method has its own advantages and disadvantages.

II. EXPERIMENTAL DETAILS

The chemical bath deposition method was used to deposit the thin films of copper selenide onto glass substrate. The reagents used for the deposition of CuSe were copper tetraoxosulphate (VI) [CuSO₄], selenium trioxosulphate (V) [SeSO₃], sodium thiosulphate [Na₂S₂O₃] as a complexing agent and ammonia (NH₃) for pH adjustment. The reaction bath was made up to 50mL and the deposition was allowed at room temperature. The cleaned glass substrate was vertically immersed in the reaction bath at room temperature. The growth parameters such as the deposition time and volume of ammonia were varied to optimize the growth. After the end of every deposition time, the substrate was taken out of the reaction bath, washed with distilled water and dried in air. The structural studies were carried out using Philips PW 1710 diffractometer with Cu-K α radiation of wavelength 1.5405 Å. The optical

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

characteristics were studied using Lambda 25UV-VISspectrophotometer(PerkinElmer), to find band gap energy of copper selenide thin films. The surface morphological studies were carried out using scanning electron microscope (JSM 6100). The average thickness of the as deposited copper selenide thin film was measured by using gravimetric method.

III. RESULTS AND DISCUSSION

3.1. Structural Analysis

X-ray diffraction patterns of chemically deposited copper selenide thin films at 353 K were recorded by varying diffraction angle (2θ) from 10 to 80 degree. Figure-1 shows the X-ray diffraction pattern of CuSe films which reveals the existence of (101), (102), (110), (116) and (208) planes. The patterns show well defined peaks suggesting that the films are crystalline.

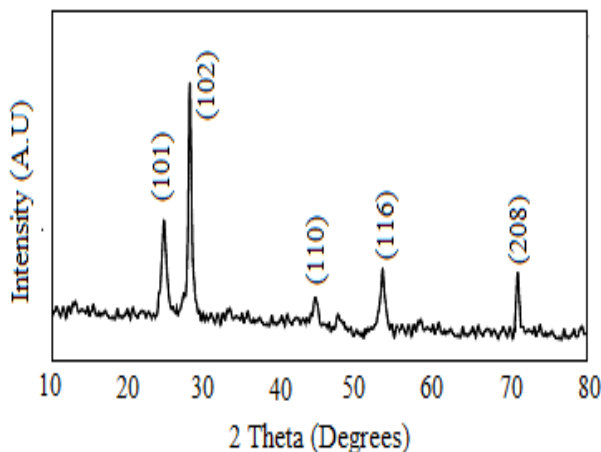


Figure1. XRD pattern of copper selenide thin film.

The XRD pattern showing (102) and (110) planes of mineral klockmannitewhich is hexagonal with composition CuSe prepared using chemical bath deposition technique.

Table1. Comparison of observed and standard XRD data of copper selenide thin films(JCPDS card 89-7391).

Film	Observed data		Standard data		hkl	phas e
	2θ (degree)	d (Å ⁰)	2θ (degree)	d (Å ⁰)		
CuS e	26.501	3.40	26.609	3.34	1 0	CuS
	28.141	2	28.101	7	1	e
	46.081	3.14	46.035	3.17	1 0	CuS
	56.607	7	56.589	2	2	e
	69.983	2.95	70.330	1.97	1 1	CuS
		8		0	0	e
		1.59		1.62	1 1	CuS
		0		5	6	e
		1.35		1.33	2 0	CuS
	1		7	8	e	

3.2. Morphology

The morphological analysis of the copper selenide thin films was carried out using Scanning electron microscope. Figure 2 shows, SEM image of copper selenide thin film. The SEM micrograph of copper selenide thin films it is clear that the grains are well defined, spherical, of almost similar sizes, which were almost uniformly distributed over a smooth homogeneous surface.

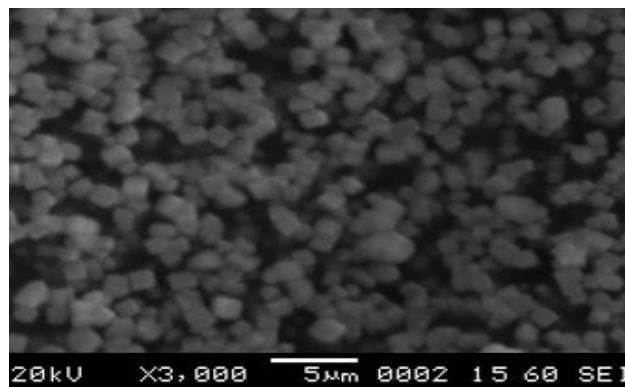


Figure 2. SEM image of copper selenide thin film

3.3. Optical Analysis

The optical band gap energy of irradiated copper selenide thin films is shown in Fig.3. The crystal size of as deposited copper selenide is 27 nm with band gap energy 2.48 eV. The photons with energies greater than the band gap energy are absorbed while photons with energies less than the band gap are transmitted. The optical absorption is characterized by the relation between the absorption coefficient(α) and the photon energy ($h\nu$) for different allowed transitions as,

$$\alpha = \frac{A(h\nu - E_g)^n}{h\nu} \quad (1)$$

Where ' α ' is absorption coefficient, A is constant, ' $h\nu$ ' is photon energy and ' E_g ' is the optical band gap energy.

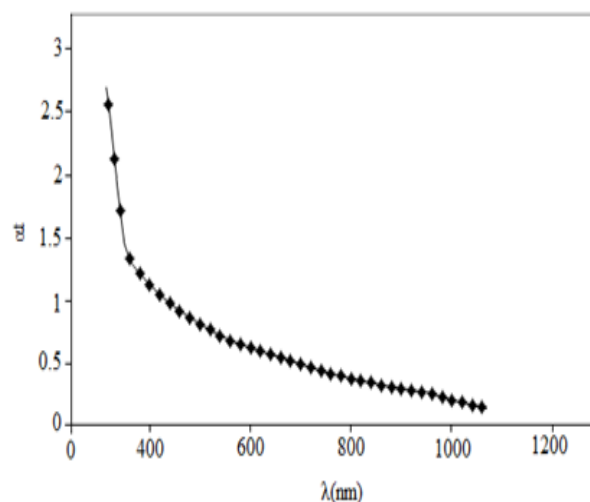


Figure 3. Variation of optical absorption vs. wavelength for copper selenide thin film

The plots of $(\alpha h\nu)^2$ versus $h\nu$ is shown in Figure 4.

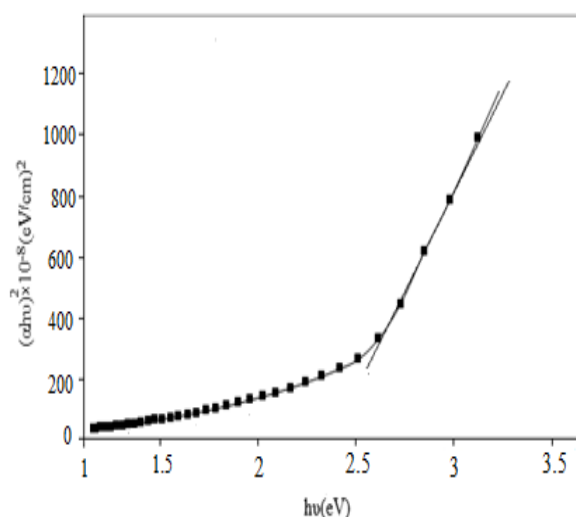


Figure4. Plot of $(\alpha h\nu)^2$ versus $h\nu$ for copper selenide thin film

Since the variation of $(\alpha h\nu)^2$ with $h\nu$ for CuSe thin film is a straight line. The linear nature of the plots indicated the existence of direct transitions. The value of E_g for as deposited copper selenide thin film was found to be 2.48 eV.

IV. CONCLUSIONS

In the present paper, physical and optical properties of chemically deposited copper selenide (CuSe) thin films at room temperature have been reported. Copper selenide thinfilms are nanocrystalline in nature with a hexagonal structure. The optical studies confirmed that chemically bath deposited copper selenide thin films exhibits band gap of the order of 2.48 eV.

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