Synthesis and Characterization of Chemically Deposited Copper Sulphide Thin Films

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Abstract: **Thin films of Copper Sulphide (CuS) were grown on glass substrates by the Chemical Bath Deposition (CBD) technique at room temperature (30^0C). Copper Chloride and Thiourea were used as sources for Copper and Sulphur ions respectively. The optical characterization was done by using a UV- VIS spectrophotometer in the wavelength range of 180 nm – 1100 nm. The transmittance of the films was determined directly from the spectrophotometer. Other properties such as absorbance and band gap were calculated. A band gap energy range between 3.00 eV to 3.41 eV was obtained and these results suggest that the films can suitably be used in the fabrication of solar cells.**

Keywords: **Chemical Bath Method, Copper Sulphide, Growth, Optical Characterization, Thin films.**

I. INTRODUCTION

A thin film is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness [1]. Thin films of transitional metal chalcogenides have received much attention due to their wide range of application in semiconducting devices such as in photovoltaic, optoelectronic devices, radiation detectors, and solar cell convertors. Among them Copper Sulfide (CuS) chalcogenides have been of much interest to researchers because they fulfill a number of the requirements for several modern electronic and optoelectronic devices such as LED's, photodiodes, blue green lasers etc. CuS is one of the direct band gap semiconductors with a wide gap which make them interesting for photovoltaic cells [2]. CuS thin films have also been of great interest in research because when they are doped they offer good window material properties [3][4][5]. Materials which include CuS, SnS and CuSnS are performing well with some of their binary and ternary combinations. CuS thin films are widely used as an absorber material in opto-electronics [6] [7].

Spray pyrolysis, sputtering, electrodeposition, vacuum evaporation, chemical vapour deposition and chemical bath deposition are widely used techniques for deposition of thin films. Chemical bath deposition (CBD) technique is easy, inexpensive and convenient method for large area preparation of thin films. Another attractive feature of the CBD method is that, ternary and quaternary compounds can be easilysynthesized without the use of any sophisticatedinstrumentation and process control [8].Chemical bath deposition (CBD) method has been widely applied successfully for the synthesis of different types of chalcogenide (CuS, CdS, SnS_2, CdSe, PbS), chalcopyrite ($CuInS_2$, $CuInSe_2$), and oxide (ZnO, CdO, TiO_2) thin film materials for different optoelectronics and solar cell devices [9].

In this paper, CuS thin films were deposited using chemical bath deposition method with different deposition time. The possible applications of the film were discovered from their properties. The absorbance (A) and the transmittance (T) were investigated and were used to calculate the band gap energy of the grown thin films.

II. EXPERIMENTAL DETAILS

2.1 Substrate preparation

The growth of CuS thin films on the glass slides was carried out using Chemical bath deposition method.The glass slides used were previously degreased in concentrated hydrochloric (Hcl) acid for 30 minutes, washed with detergent, rinsed with distilled water and allowed to dry in air.

2.2 Deposition of the CuS thin films

5ml of 1.0M Cuprous Chloridewas mixed with 5ml of 1.0M Thiourea, 3ml of TEA, 3ml of 0.1M EDTA, 10ml of distilled water and 3ml of ammonia solution was added slowly to the mixture. The mixture was then stirred with a magnetic stirrer to give a homogeneous mixture.The pH of the precursor was measured and recorded to be 10.14 which shows that the reaction bath is the alkaline medium and the temperature was noted to be 30^0C. The glass slides were inserted vertically in to the precursor for 1hour, 2hours, 3hours and 4hours for samples C_1 - C_4. Sample C_0 serves as a control for all other slides. After maximum deposition time the glass slides were removed and dried, annealing of the slides was done by inserting the slides in the oven for 30 minutes at different temperatures.

Table 1: Deposition parameters of CuS thin films

S/No	Samples	Deposition time(hours)	Annealed time(mins)	Annealed temp (^{0}C)
1.	Sample C_0	0.0	0	0^0C
2.	Sample C_1	1.0	30	50^oC
3.	Sample C_2	2.0	30	100^oC
4.	Sample C_3	3.0	30	150^oC
5.	Sample C_4	4.0	30	200^oC

III. RESULTS AND DISCUSSION

The optical property was measured in the 180nm – 1100nm wavelength interval using a UV- VIS 3700 Spectrophotometer. From the value of transmittance obtained, other properties such as film absorbance and band gap energy were obtained through theoretical calculations.

3.1 Absorbance

The spectra absorbance variation with its wavelength for the entire sample is shown in figure 1. The spectra clearly indicate that lower wavelength corresponds to maximum absorption compared to higher wavelength. This is in agreement with the result gotten by other researcher [10]. Highest absorbance value of 5.3 at 250nm was obtained for the film grown at 4 hours(C_4) while the least absorbance value of -0.5 at 190nm was obtained for the film grown at 1hour (C_1). The result shows that these films have high absorbance in UV region and low absorbance in VIS- NIR region.

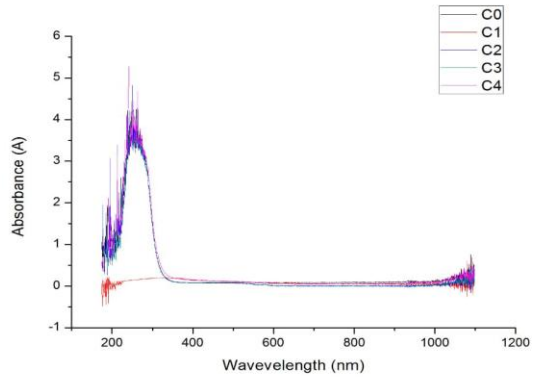

Figure 1: Absorbance Spectra versus wavelength of CuS Thin Films

3.2 Transmittance

Figure 2 shows the plot of transmittance against the wavelength. The transmittance of the film increases with increase in wavelength except for sample C_1 which decreases with increase in wavelength in the UV region and later increases in the visible region. This results obtained show that the transmittance of the films is low in UV region but high in VIS - NIR regions.

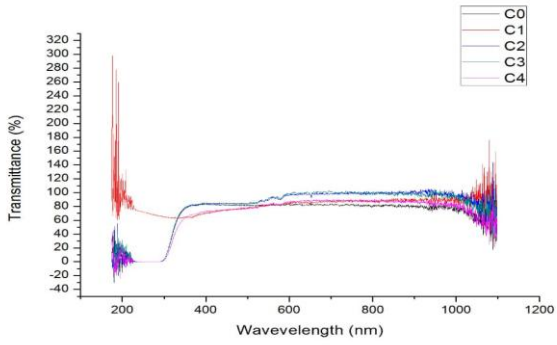

Figure 2: Transmittance Spectra versus wavelength of CuS Thin Films

3.3 Band gap

Figure 3 shows the plot of absorption coefficient times (hv) squared against the photon energy. From the graph, the band gap energy of the films was determined. The result shows that sample C_1 has a band gap of 3.30eV,sample C_2 has a band gap of 3.35eV, sample C_3 has a band gap of 3.41eV and sample C_4 has a band gap of 3.00eV. These results show that the value ranges from 3.00 eV to 3.41eV. This implies that CuS thin film is a wide band energy material and can be used as a window layer of a solar cell.

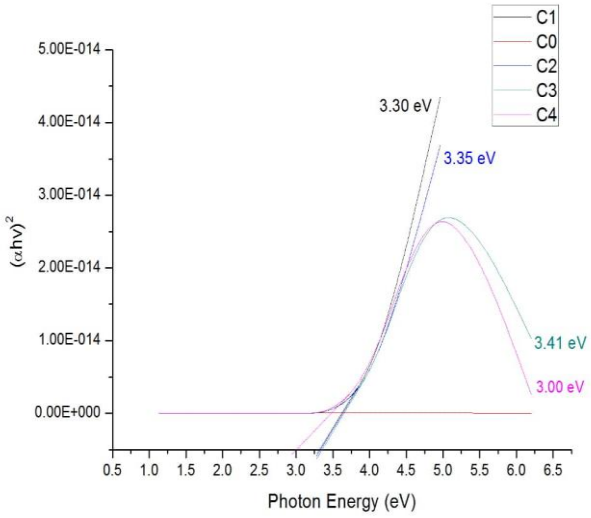

Figure 3: Graph of $(\alpha hv)^2$ versus Photon energy(eV)

IV. CONCLUSION

Binary thin films of Copper Sulphide have been grown on glass substrate using chemical bath method at varying time at room temperature and characterized using a Spectrophotometer to determine its optical properties. The absorbance of the film is high in UV region and low in VIS NIR region while the transmittance is low in UV region and high in VIS – NIR regions. The energy band gap of the film obtained is between 3.00eV and 3.41eV. These results suggest that the films can suitably be used in the fabrication of solar cells.

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