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Chemical Bath Fabrication of Copper sulfide (Cus) Thin Films, Structural and Optical Characterization in an Alkaline medium

Hansraj Bharat Athwale[1]; Dr. G. P. Urkude[2]

[2]Guide

[1,2]Shri Shivaji College Parbhani

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Abstract: Copper sulfide (Cus) thin film is a p-type semiconductor material considerably used in photovoltaic applications cus thin films have been deposited on a glass substrate by using the chemical bath deposition method on glass slides substrate at room temperature , The chemical bath deposition method at 50^0 c temperature aqueous solutions of copper sulfide $Cuso_4$, Thiourea $Sc(NH_2)_2$, Ammonia solutions NH_4 , Triethanolamine $C_6H_{15}NO_3$ and Tartaric acid $C_4H_6O_6$.

The structural properties of the prepared thin films were characterized using X-ray diffraction (XRD) analysis show that the thin films are high crystalline in nature ,the surface morphology and elemental composition of the thin films were analysis using Scanning Electron Microscopy (SEM) and Energy -Dispersive X-ray analysis (EDAX)

The optical properties were study by U-V Spectrometer in visible to infrared region ,The optical absorption behavior reveals important characteristics such as electronic transitions, optical band gap ,and the suitability of the material for optoelectronic and photovoltaic applications.

Keywords: *Cus, Chemical Bath Deposition Method ,XRD ,SEM, EDAX ,U-V Etc.*

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I. INTRODUCTION

Copper sulfide (cus) is recognized as an important p-type semiconductor with significant potential for use in various technological optoelectronic and photovoltaic applications, The material possesses excellent optical, electronic, physical, and chemical characteristics.

The thin film of cus have been widely investigated because of their potential use in solar cells, photodetector, electrochemical devices, microwave shielding and smart coating technologies. The performance of cus thin films is strongly influenced by factors such as deposition conditions film thickness, composition, and impurity concentration.

The optical absorption and transmission over a selected wavelength range, the optical absorption important characteristics such as electronic transitions, optical band gap and suitability of the material for optoelectronic and photovoltaic applications.

The absorption of photons occurs when the energy of the incident light is equal to or greater than the band gap of the semiconductor .the electrons from the valence band to the conduction band. These optical characteristics play a significant role in assessing the potential of thin films for applications such as solar cels ,photodetectors, and other optoelectronic devices .

II. MATERIALS AND METHODS

- *Preparation of Glass Substrate:*

Glass substrates were cleaned thoroughly before the deposition process ,initially the slides were immersed in concentrated hydrochloric acid (HCL) for 30 minutes to eliminate surface impurities ,They were than washed with a ethanol solution. rinsed several times using distilled water and finally air-dried before being used for thin film deposition .

- *Deposition of Cus Thin Films:*

Cus thin films were synthesized using the chemical bath deposition (CBD) method .The precursor solution was

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prepared by mixing 15 ml of 0.1m copper sulphate with 15 ml of 0.1m tartaric acid and 15 ml of 0.1 m thiourea followed by the addition of triethanolamine 1.5 ml and 50 ml of distilled water subsequently ,Ammonia solution was added slowly while continuously stirring the solution with a magnetic stirrer to obtain a uniform reaction mixture . The PH of the bath was adjusted to approximately 10-12,and the deposition temperature was maintained at about 50^0 c in a water bath and clean glass substrates were immersed vertically for film deposition samples were withdrawn after deposition 40 minutes the growth of the cus thin films .

It was observed that deposition was essentially complete after 25 minutes .After deposition the coated glass substrate were rinsed thoroughly with running water to remove loosely attached particles followed by washing with deionized water finally the films were air-dried before further characterization.

III. RESULTS AND DISCUSSION

➢ *XRD Studies.*

The X-ray diffraction (XRD) pattern of the Cus thin film deposited on the substrate is presented in fig .The diffraction profile was recorded over the 2θ range of approximately 10^0-90^0 by using cuka radiation (λ=1.5406 A^0)

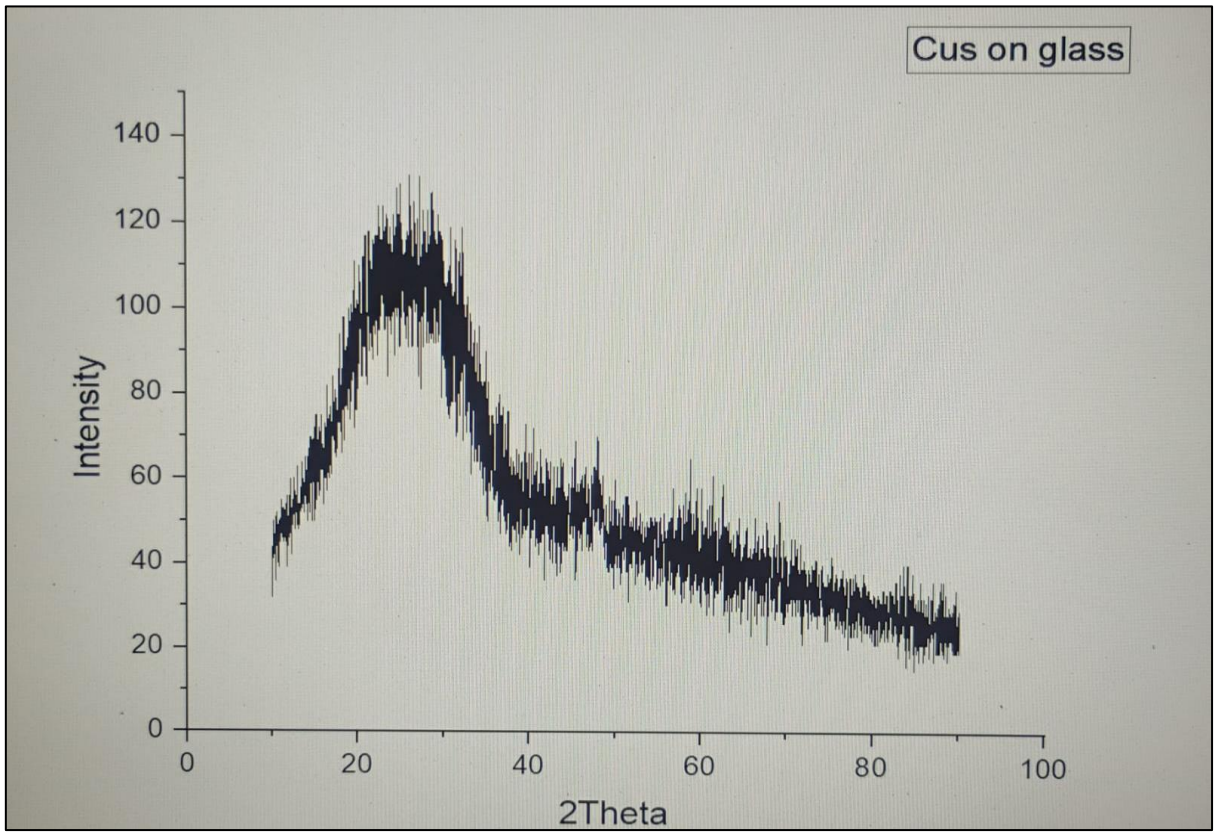

Figure 1 XRD Results of Cus Deposited on Glass

The X-ray diffraction pattern exhibits a broad diffraction band extending from approximately 20^0 to 35^0 with the maximum intensity observed near 27^0. The absence of shape and intense diffraction peaks suggests that the deposited cus layer possesses low crystallinity and is predominantly amorphous in nature .

The crystal structure of the deposited Cus thin film was investigated using X-ray diffraction XRD. The diffraction pattern exhibits well-defined peaks at 2θ= 27.7^0 , 29.3^0, 31.8^0 , 32.8^0 , 47.9^0 , 52.7^0, and 59.3^0 .The corresponding interplanar spacing (d-spacing) values were calculated as 3.21 A^0, 3.05 A^0 , 2.81 A^0 , 2.75 A^0 ,1.90 A^0 , 1.74 A^0 and 1.56 A^0 respectively .

The observed diffraction peaks were indexed to the crystallographic planes (101) , (102) , (103) , (006), (110) , (108) , and (116), indicating the successful formation of crystalline cus thin films. The sharp and distinct diffraction peaks confirm the polycrystalline nature of the deposited film . The prominent diffraction peak corresponding to the (101) plane suggests a preferred orientation of crystal growth along this direction. These structural characteristics are advantageous for several optoelectronic and photovoltaic applications.

➢ *Surface Morphology of the Thin Film:*

The surface morphology of the cus thin film was investigated by using Scanning Electron Microscopy (SEM) at different magnification of 40kx,50kx,and 100kx .The SEM micrographs demonstrate that the deposited cus thin film uniformly covers the substrate and exhibits a compact nanocrystalline surface morphology.

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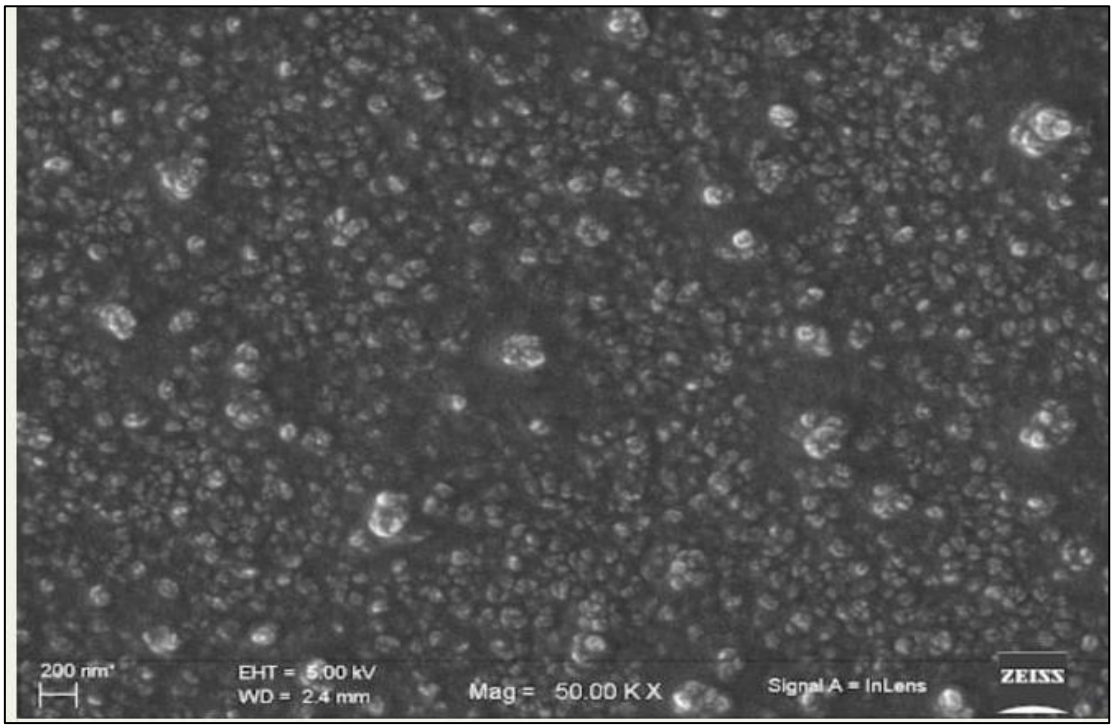

Fig 2 Surface Morphology of the Cus Thin Film obtained by SEM

The SEM image shown in fig SEM micrograph the granular structure ,the nano-grains are closely packed and interconnected, nanocrystalline granular morphology .This morphology indicates improved crystallization and grain growth, which are expected to facilitate efficient charge transparent by reducing grain boundary resistance .

➢ *EDAX:*

The compositional analysis of copper sulfide is an show in fig chemical composition for bath concentration 0.1m and 40 min, deposition time was carried out by Energy – Dispersive X-ray analysis . The obtained spectrum exhibits characteristic peaks corresponding to copper (cu) and sulfur (s) confirming the successful formation of the copper sulfide phase.

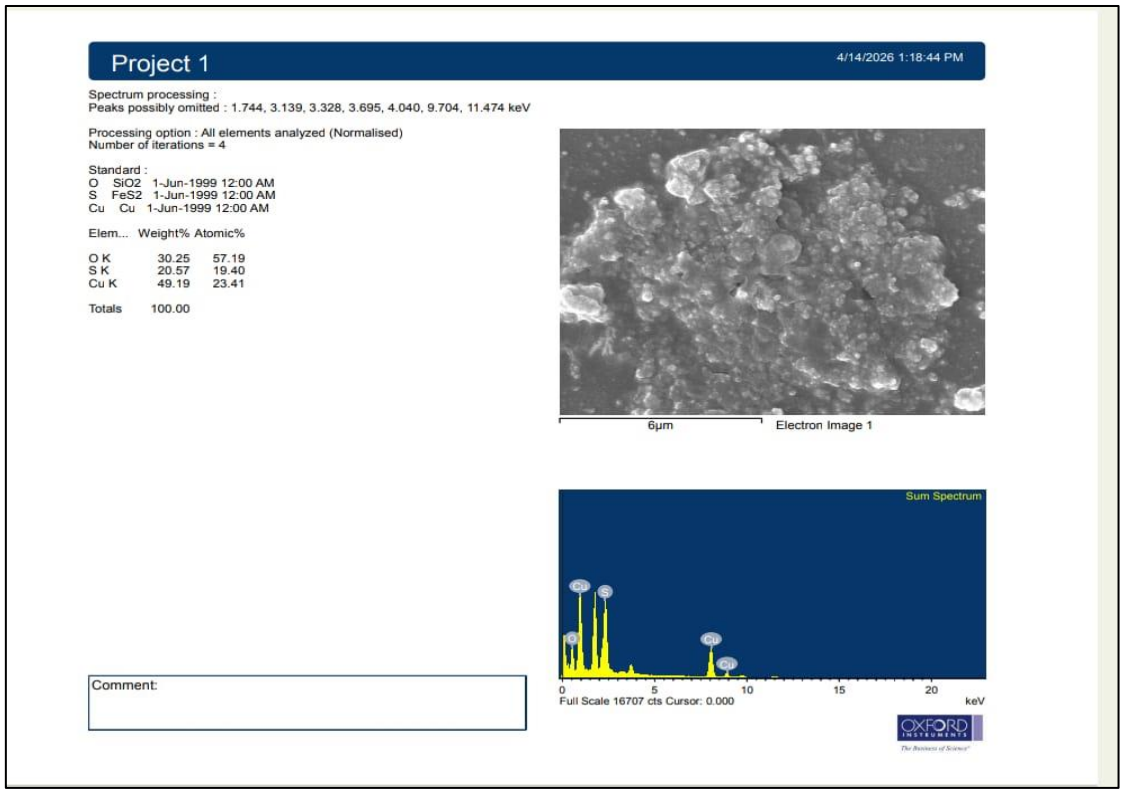

Fig 3 EDAX Spectrum of Cus Thin Film

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The EDAX analysis show that the film contains approximately 49.19 wt % Cu , 20.57 wt % S and 30.25 wt % O. The elemental mapping images reveal a nearly uniform spatial distribution of cu and s throughout the analyzed region distribution of cu and s throughout the analyzed region distribution without significant elemental segregation .

This homogeneous distribution indicates that the deposited cus thin film possesses good composition uniformly, The deposited cus thin film is chemically uniform and suitable for further structural optical and electrical characterization.

➢ *UV – Visible Spectral Analysis:*

The optical absorption properties of the thin film were investigated using a uv- visible spectrophotometer in the wavelength range of 200-1100 nm.

The absorption spectrum shows strong absorption in the ultraviolet region indicating that the film effectively absorbs high-energy photons .The absorption intensity remains very high between 221 and 297 nm suggesting that electronic transitions occur readily in this region. The major absorption peak was observed at 347 nm with an absorbance of 2.265. While very high absorbance (≈ 4.0)

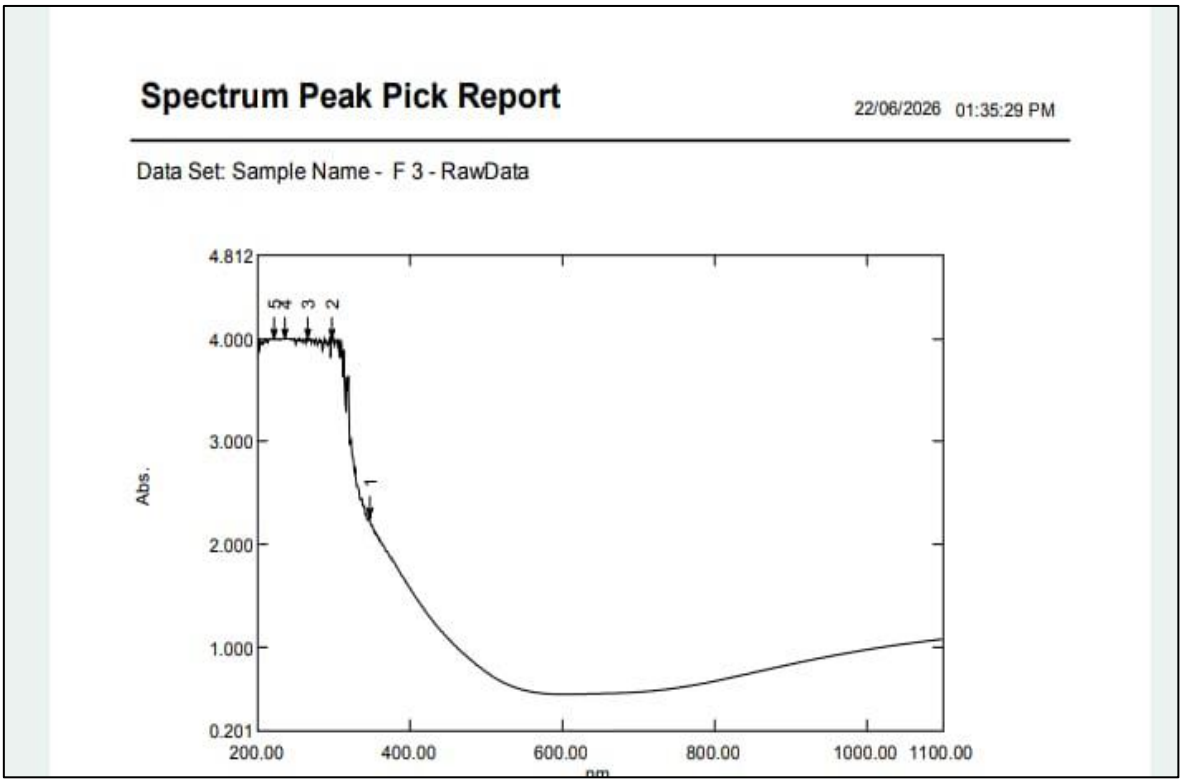

Fig 4 UV-Visible Absorption Spectrum of Cus Thin Film

➢ *I-V Characteristics of the Cus Thin Film:*

The current -voltage (I-V) characteristics of the deposited thin film were investigated the voltage range of -3 to +3v to evaluate its electrical transport behavior as shown in the graph .In the negative bias region the current reaches about -1.45×10^{-7}A at -3v .As the applied voltage approaches zero . the magnitude of the current decreases steadily and passes through the origin with only a negligible off set indicating a low leakage current under positive bias the current increases continuously reaching approximately 1.28×10^{-7A} at +3 v.

The nearly straight -line variation of current with voltage indicates that the electrical conduction follows ohm·s law suggesting the formation of good electrical contacts between the thin film and the electrodes.

The measured current remains in the order of 10^{-7}A indicating controlled charge transport with relatively low current flow such behavior is typical of semiconducting thin films .where the conductivity is governed by thermally activated charge carries and grain -boundary scattering .

The I-V characteristics demonstrate a stable nearly ohmic and symmetric electrical response the deposited thin film possesses good electrical conductivity and is suitable for use in electronic and optoelectronic device applications.

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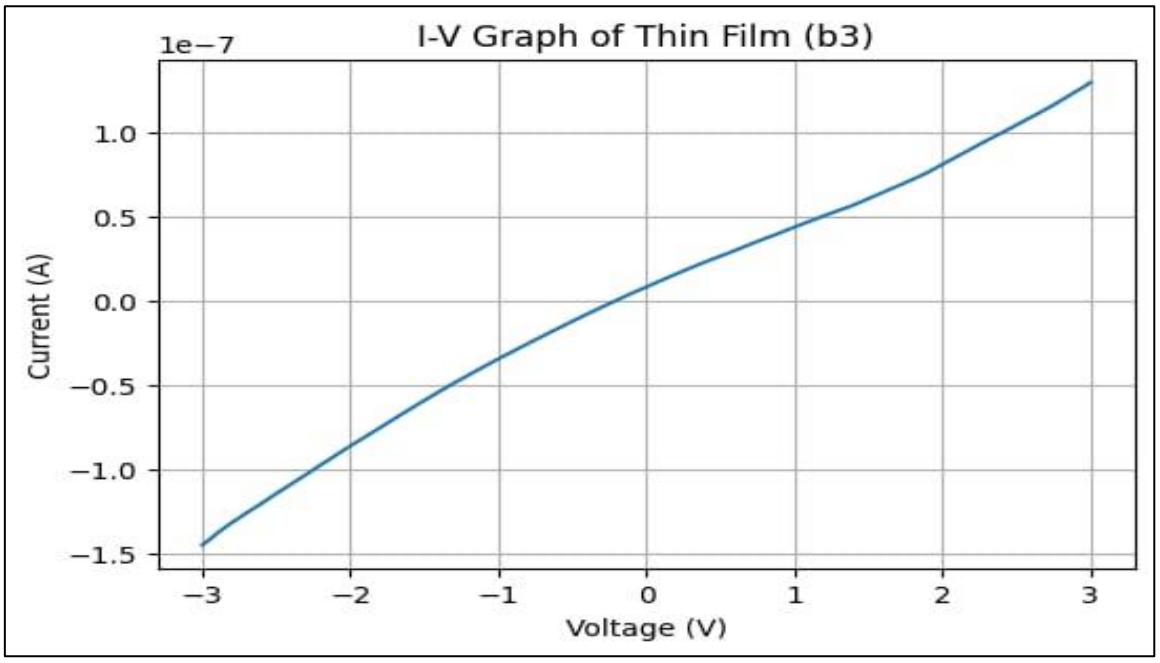

Fig 5 I -V Characteristics of Cus Thin Film

IV. CONCLUSION

The x-ray diffraction (XRD) analysis confirmed the successful formation of crystalline cus thin films deposited on glass substrates .The diffraction peaks indicates the polycrystalline nature of the deposited film with good crystallinity .

The SEM deposited cus thin film exhibits a dense and continuous surface morphology with uniformly distributed nanoscale grains crystallites with only minor agglomeration in a few regions . The SEM-EDAX analysis confirmed the successful deposition of the cus thin film on the glass substrate.

The UV-Visible absorption analysis demonstrated that the synthesized cus thin film exhibits strong optical absorption in the ultraviolet region. The current -voltage (I-V) characteristics of the deposited cus thin film demonstrate a nearly linear relationship between the applied voltage and the measured current over the investigated voltage range ,The measured current ,which is in the microampere range (10^{-7}) ,confirms the semiconducting behavior of the cus thin films.

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