STRUCTURAL AND OPTICAL CHARACTERIZATION CuO THIN FILMS BY SILAR METHOD

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ABSTRACT:

Copper oxide (CuO) thin films were synthesized and characterized for their structural, optical properties. In this study, CuO thin films were deposited using SILAR Method on glass slide . X-ray diffraction (XRD) analysis confirmed the monoclinic phase of CuO with well-defined peaks, indicating good crystallinity. The average crystallite size was estimated using the Scherrer equation. UV-Visible spectroscopy revealed a strong absorption in the visible region, with a calculated optical bandgap in the range of 1.3 eV, confirming the semiconductor nature of the films. The combination of structural, optical, and electrochemical properties suggests that CuO thin films have significant potential Mainly in supercapacitor applications.

KEY WORDS: CuO, Thin Film, XRD, UV-vis, Characterization techniques.

INTRODUCTION :

Copper Oxide (CuO) is a p-type semiconductor with a narrow band gap, good electrical conductivity and excellent optical properties. It has promising applications in gas sensors , solar cells , supercapacitor and photocatalysis. The structural, morphological and electrical properties of CuO Thin Films make them suitable for various optoelectronic and energy applications. [10] The aim of the project is to synthesize and characterize CuO Thin Films, to analyse the crystallinity and phase composition using X-ray diffraction (XRD) and to examine the Absorption Bandgap Using UV-Visible Spectroscopy.

MATERIALS AND METHODS :

Substrate : Glass slides

Precursors :

$[Cu(NH3)4]_2+$ (Copper-Ammonia complex as Cationic solution)

Hot Distilled water as Anionic solution

Solvent : Deionized water for solution preparation.

Characterization Tools :

- X-Ray Diffraction(XRD) for structural analysis.
- UV-Vis Spectroscopy for Optical analysis and Bandgap Energy.

METHODOLOGY :

Substrate Preparation:

Clean the substrate ultrasonically for 15 minutes in dilute hydrochloric acid, acetone, and ethanol. Rinse the substrate in distilled water for 7 seconds and let it dry in air.

Cationic Solution Preparation:

Dissolve 0.1 M of CuCl2.2H2O in 100 ml of distilled water. Stir continuously to yield a homogeneous solution. Adjust the pH of the solution to 10 by adding Ammonia (NH3, 25-28%).

SILAR Deposition:

The substrate is dipped in the $[Cu(NH3)4]_2$ and solution for 30 seconds. The substrate is dipped in hot distilled water (80°C) for 30 seconds and Let the substrate dry in air for 7 seconds. Repeat the above steps for 20, 40, and 60 cycles.

RESULT AND DISCUSSION :

The principle of XRD is based on Bragg's Law, which states that:

$$n\lambda = 2d \sin(\theta)$$

where:

n is an integer

λ is the wavelength of the X-rays

d is the spacing between the crystal planes

θ is the angle of incidence and reflection

XRD is used to determine the crystallinity, phase composition, and grain size of the CuO thin films, using JCPDS file No 48-1548 for reference.

$$D = k\lambda / \beta \cos \theta$$

Where:

D = crystallite size (nm)

K = Scherrer constant

λ = X-ray wavelength

β = Full Width at Half Maximum (FWHM)

θ = Bragg's angle in degrees

The dislocation density has been calculated using crystallite size by the equation,

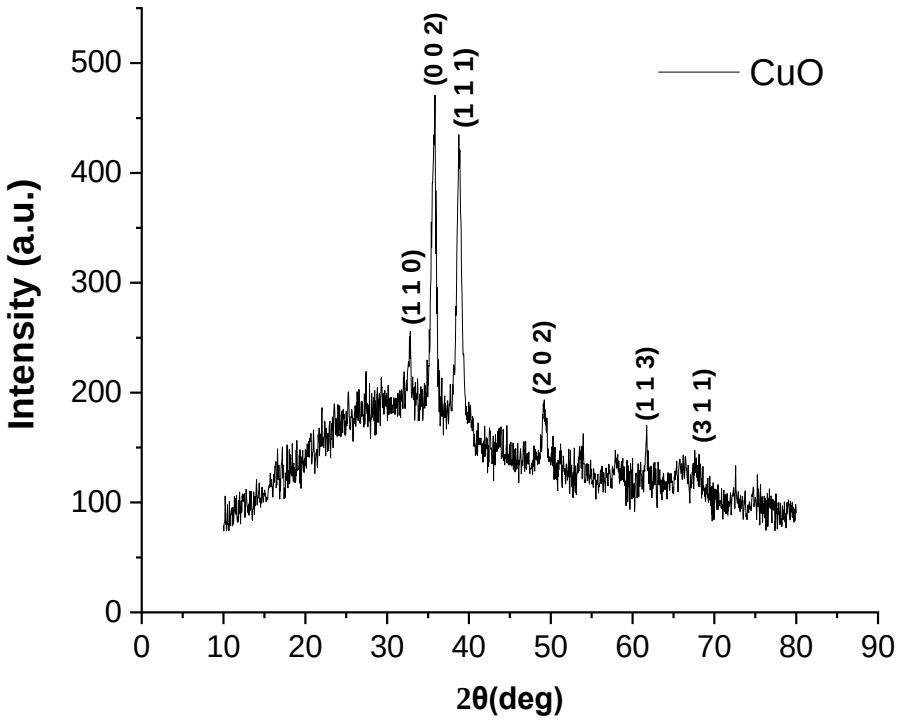
Dislocation = 1/D2

The micro strain has been calculated by the given formula,

Micro strain = β cos / 4

The lattice parameter calculated for CuO by the given formula,

Deposition Cycle	h k l	2θ (degree)	Grain size(nm)	Dislocation Density (lines/m^2)	Micro strain (10^{-4})	Lattice constant(Å)
60	1 1 0	32.7323	17.53	0.00325	0.00702	a = 4.683 Å
	0 0 2	35.7464	15.15	0.00436	0.00746	b = 3.422 Å
	1 1 1	38.7941	17.83	0.00314	0.00585	c = 5.132 Å
	2 0 2	49.2175	13.87	0.00520	0.00600	β = 99.54°
	1 1 3	61.7228	19.59	0.00260	0.00345	
	3 1 1	66.7514	2.52	0.15776	0.02503	



XRD GRAPH

XRD CALCULATION TABLE

UV-Vis Spectroscopy :

The optical bandgap of CuO Thin Film was measured using Tauc's Plot:

$$(\alpha h\nu)^n = A (h\nu - Eg)$$

The bandgap was found to be ~1.4 eV Suitable for Solar and sensor applications.

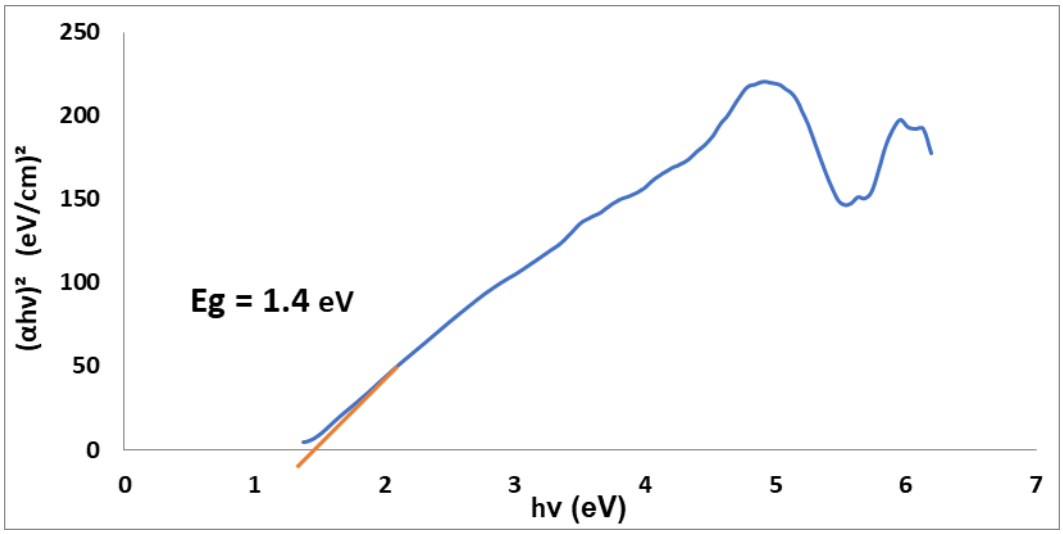
ELECTRICAL PROPERTY:

The film exhibited good p-type conductivity which is useful for electronic applications.

CONCLUSION :

- CuO Thin Films were successfully synthesized using SILAR Method.
- The films exhibit Monoclinic CuO structure, good crystallinity and uniform morphology.
- It is Suitable for Solar cells , sensors and electronic applications.

UV-VIS SPECTROSCOPY:



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