International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Impact Factor: 6.882, Volume 05, No. 01(III), January - March, 2023, pp. 17-22

A STUDY OF DEPOSITION AND CHARACTERIZATION OF COPPER OXIDE THIN FILM BY THERMAL VAPOUR DEPOSITION

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ABSTRACT

A crucial tool for the deposition of nanostructured thin films is thermal vapor deposition. The technique is explained in detail in this study. This describes the physical vapor deposition process used to build a thin layer of copper oxide on a silicon substrate. The average thickness of physical vapor deposition is 2 to 5 microns, and it is a family of deposition procedures where we evaporate our sample and deposit that via condensation onto a substrate. X-Ray diffraction (XRD), field emission scanning electron microscopy (FESEM), Photoluminescence and UV-Vis were used to characterize these films.

Keywords: *FESEM, XRD, Nanostructured Thin Films, Copper Oxide, Silicon Substrate.*

Introduction

Semiconductors include copper oxides. CuO and cuprous oxide are the two stable oxides in the CuO system (Cu_2O). These two oxides have visible or near-infrared band gaps, making them semiconductor. These materials have a number of advantages: starving materials are readily available and plentiful they're non-toxic, their manufacturing costs are inexpensive, their band gaps are within acceptable bounds for the conversion of solar energy, and they exhibit both n- and p-type conductivity. Direct band gaps in copper oxide films range from 1.2 to 2.6 eV. They have a wide range of uses, such as solar cells, sensors, and optoelectronic industries. The purpose of this research is to examine the characteristics of copper oxide thin films under physical vapor deposition. Discussions follows the results based on the structural, optical, and morphological qualities. CuO and $Cu_2O$are the two main forms of copper oxide, with CuO having a monoclinic structure and Cu_2O having a cubical structure with a lattice parameter of 4.2 angstrom. Both foils have excellent electrical and optical qualities, which allows us to employ them in a variety of applications, including solar cells. In the current study, we oxidized copper thin films by thermal evaporation in a vacuum chamber on silicon substrates before depositing thin films of copper oxides. With the help of X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and UV-Vis, the structure and composition of these films were identified. In the process of thermal evaporation, the target material is located inside an evaporation source (boat, coil, and basket) which is heated by the passage of electric current. The target material inside the evaporation source is heated to the evaporation point. Because heat generation is due to electrical resistance of the evaporation source, this method is also called resistive evaporation. After evaporation, the molecules of the target material move to the substrate and form a thin film on the surface of the substrate. Many materials can be deposited using this method, including Aluminum, Silver, Nickel, Chromium, Magnesium, etc.

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Methodology

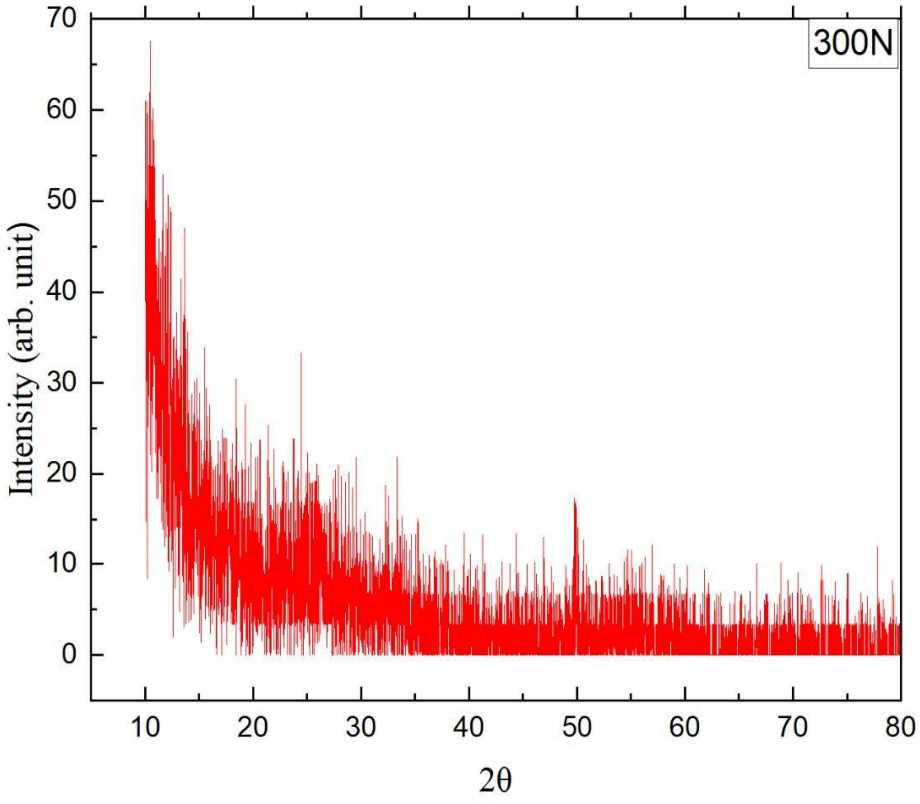
This thin layer of copper oxide was applied in a thermal vacuum evaporator to silicon wafers(resistance of 5 to 10 ohms cm). Prior to being loaded into the vacuum chamber, the silicon substrate was ultrasonically cleaned with acetone, isopropanol, and methanol for about 15 minutes, followed by drying. The entire procedure was carried out at a high pressure of the order of 10^{-6} torr. However, during deposition, the pressure may be of a different order. This experiment demonstrated a linear relationship between the evaporated mass and the evaporated film thickness. In order to create thin films, a tungsten boat was used.

The initial substance was red Cu_2O powder. In a box being pumped by a diffusion pump, thin films were created. Before the substance evaporated, it gently outgassed. film was applied to a heated substrate. Using a variety of analytical techniques, the structural, morphological, optical, and chemical characteristics of all copper oxides were characterized. The X-ray diffractometer was used to examine the crystallographic structures. Cu-K radiation (wavelength = 1.54) with an accelerating potential of 30 kV and an emission current of 15 mA was employed as an X-ray source. With a field emission scanning electron microscope (FESEM) from Nova Nano Sem 450, operated from 0.5 to 30 kV, the surface morphology of the copper oxide layers was examined. Using a UV-visible optical spectrometer, the optical transmittance of the oxide films was measured in the wavelength range of 200-700 nm, and the optical band gap of the oxide films was determined. Using Photoluminescence we found out that our film was optically active.

Results and Discussion

X-Ray Diffraction

The structure of sample was studied by X-ray diffraction (XRD) using a conventional X-ray diffractometer. The XRD patterns were recorded in the 2θ range from 10◦ to 80◦. All the XRD patterns of samples are shown in Fig. The presence of several diffraction peaks, clearly depict the polycrystalline nature of samples.



The primary use of the technique is the identification and characterization of compound based on their diffraction pattern.

The basic component of X-Ray diffraction are:

- X-Ray source
- sample
- X-Ray detector

Bragg's Equation

nλ = 2dsinɵ

From this we can determine the structure and the lattice parameter of the material. As of right now, crystallites make up the prepared samples. Therefore, using the well-known Debye-Scherrer equation, the crystallite sizes are approximated as,

Crystallitesize (d)= kλ/βcosɵ

Where, k=scherrer's constant

λ=X-ray wavelength

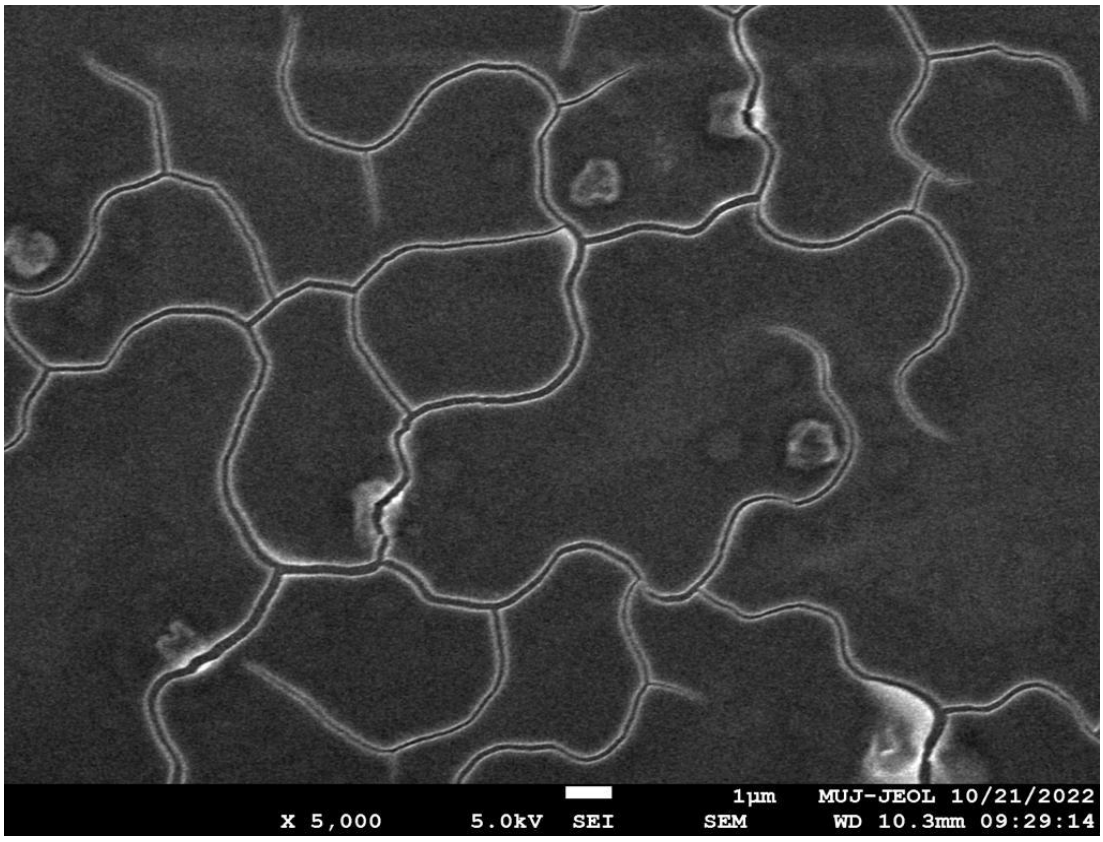
β=FWHM

ɵ=Angle of diffraction

Surface Morphology

The surface morphology of the various CuO films was examined using FESEM.

The structure of sample was studied by Field emission scanning electron microscopy (FESEM) provides topographical and elemental information at magnifications of 10x to 300,000x, with virtually unlimited depth of field. Compared with convention scanning electron microscopy (SEM), field emission SEM (FESEM) produces clearer, less electrostatically distorted images with spatial resolution down to 1 1/2 nanometers – three to six times better.



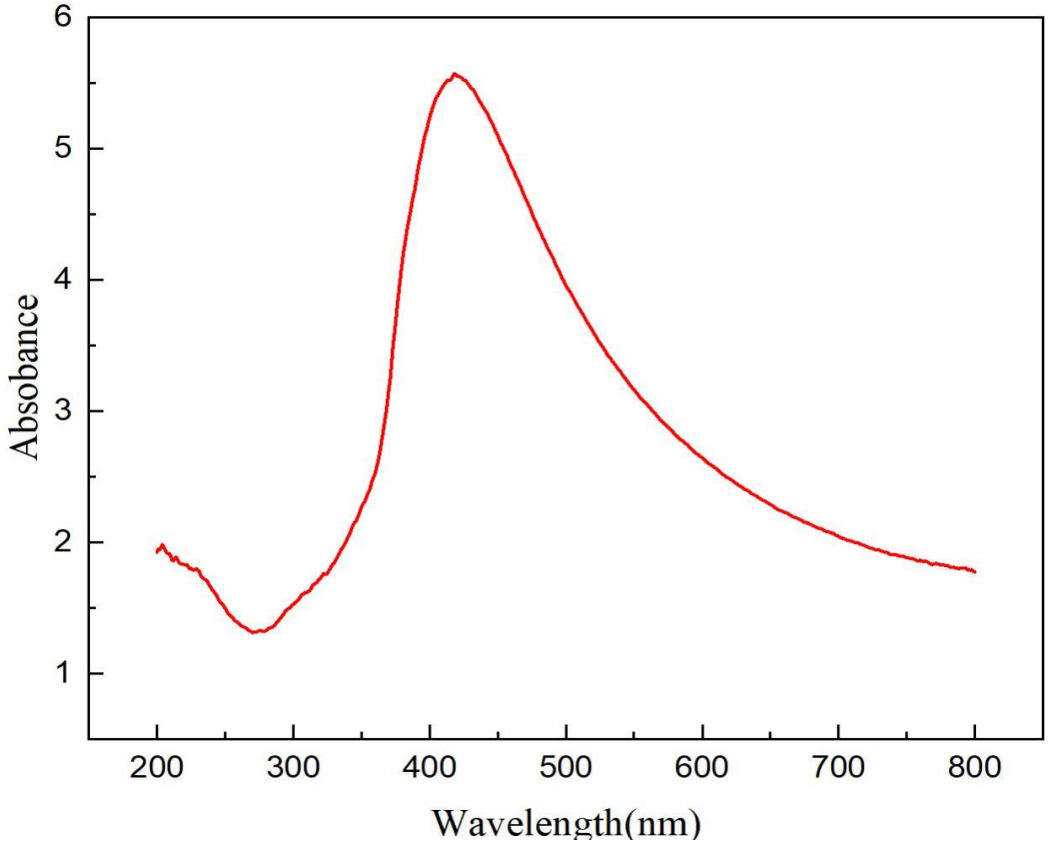
A field-emission cathode in the electron gun of a scanning electron microscope provides narrower probing beams at low as well as high electron energy, resulting in both improved spatial resolution and minimized sample charging and damage. For applications that demand the highest magnification possible.

The FESEM is one microscope that works with electron with a negative charge instead.

Ultraviolet–Visible Spectroscopy

Optical Properties

UV-visible spectrum analysis was used to identify the optical characteristics and the optical bandgap. graph displays information from absorbance coefficients of the CuO films created by PVD



UV–visible spectroscopy is based on the measurement of the ratio of the passed light with respect to the incident light in the wavelength range from the UV to the visible.

UV-Vis light is pass through a sample and the transmittance of light by the sample is measured and It is very versatile and able to detect nearly every molecule

T = I/J (it takes value between 0 and 1)

T = transmittance

I = incident intensity

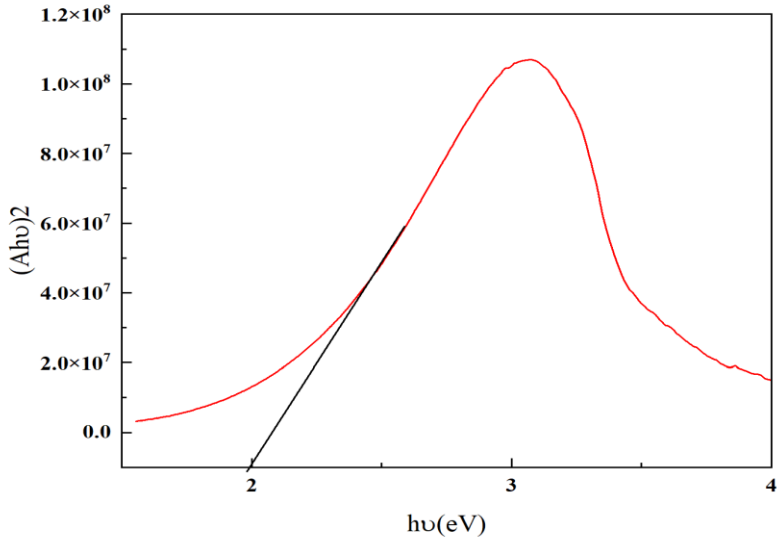
J = transmitted intensity

A = ln(I/J)

A = -ln(T)

A = absorbance

CuO absorbs more light than other materials in the visible spectrum, up to 900 nm, and more strongly in the ultraviolet region, up to 600 nm. This concurs with an earlier study



The surface shape was closely related to the absorption characteristics. The optical bandgap of the films is calculated using Tauc's equation.

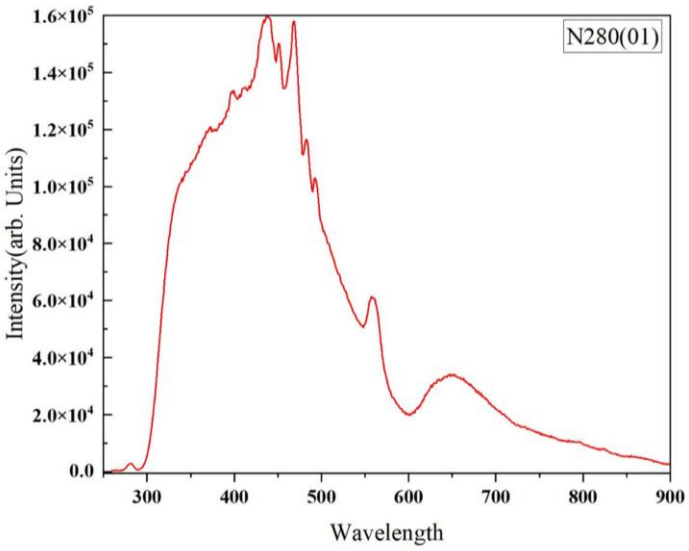
αhv = η$(hv - Eg)$

Where η is a constant, hv is the energy of the incident photon, andα is the absorption coefficient, The optical bandgap is Eg, and for the permitted direct transitions, r = 1/2.

Photoluminescence

Photoluminescence is a process in which a molecule absorbs a photon in the visible region, exciting one of its electrons to a higher electronic excited state, and then radiates a photon as the electron returns to a lower energy state.

Photoluminescence (PL) is used to investigate the separation of photogenerated charge carriers because the PL signal generally resulted from recombination of photogenerated electron-hole pairs. Thus, high PL intensity indicates more recombination of charge carriers, whereas lower PL intensity suggests the maximum separation of charge carriers, which is very useful for efficient photocatalytic performance



Conclusion

Copper oxide nanoparticle thickness film was Physical vapourdeposition and we characterized the thin film using XRD, FESEM and UV-visible spectroscopy and Photoluminescence. We obtained the peak at preffered orientations along (200) planes confirms polycrystalline nature and nearly hexagonal structure of copper oxide nano structural thin film. Energy band of sample is 2eV. The sample is optically active since it is giving good PL response.

References

1. Moumen A, Hartiti B, Thevenin P and Siadat M 2017 Synthesis and characterization of CuO thin films grown by chemical spray pyrolysis Opt. Quantum Electron. 49
2. Jilani A, Abdel-wahab M S and Hammad A H 2017 Advance Deposition Techniques for Thin Film and Coating Mod. Technol. Creat. Thin-film Syst. Coatings
3. Rabih L, Ali G G and Younus M H 2019 Evaluation of optical and electrical properties of TiO2 thin films doped Cu ions AIP Conf. Proc. 2201
4. Mahalingam T, Chitra J S P, Chu J P, Moon H, Kwon H J and Kim Y D 2006 Photoelectrochemical solar cell studies on electroplated cuprous oxide thin films J. Mater. Sci. Mater. Electron. 17 519–23
5. Fu L J, Gao J, Zhang T, Cao Q, Yang L C, Wu Y P and Holze R 2007 Effect of Cu2O coating on graphite as anode material of lithium ion battery in PC-based electrolyte J. Power Sources 171 904–7
6. Photodetector H N, Wang S, Hsiao C, Chang S, Member S, Jiao Z Y and Young S 2013 ZnO Branched Nanowires and the p-CuO / n- ZnO Branched Nanowires and the p-CuO / n-ZnO 12 263–9
7. Jin Z, Zhang X, Li Y, Li S and Lu G 2007 5.1% Apparent quantum efficiency for stable hydrogen generation over eosin-sensitizedCuO/TiO2 photocatalyst under visible light irradiation Catal. Commun. 8 1267–73
8. Simons D S, Chi P H, Nakamura Y, Zhuang H and Kishimoto A 1998 Enhanced CO and CO2 Gas Sensitivity of the CuO/ZnO Heterocontact Made by Quenched CuO Ceramics Yoshinobu 145 632–8.