Vinaya P P
vinayparal@gmail.com

Dr.Dhanajaya kekuda
kekuda@gmail.com

Department of Science,
Manipal University,
Manipal, Karnataka,
India.

STUDY OF OPTICAL PROPERTIES OF CuO THIN FILMS GROWN BY SPIN COATING TECHNIQUE

***Abstract*- Copper oxide (CuO) thin films were coated on glass substrate by spin coating method. In this work we were mainly studied the optical properties of CuO film using UV spectrophotometer, physical properties studied by using x ray diffraction and atomic force microscopy. We have measured the parameters such as optical band gap varying the processing parameters like annealing temperature, spin speed etc. Amorphous nature of the thin films was revealed from the x-ray diffraction. The surface analysis of the films was done with an Atomic Force Microscope.**

***Index Terms*— Spin coating, XRD, UV visible spectrometer, AFM, Glass substrate.**

I. INTRODUCTION

Solar cell technology for future energy resources has been progressed recently. Silicon is used as the semiconductor material for conventional solar cells, and the cost reduction of the solar cells is one of the most important issues. In metal oxide CuO is attractive because the metals are abundant on earth, inexpensive and non-toxic. Moreover, these oxides have useful optical and electrical properties suitable for a wide variety of electrical devices in Copper oxides such as CuO and Cu_2O are one of the candidate materials. The features of copper oxide semiconductors are high optical absorption coefficient. CuO and Cu_2O are p-type semiconductors with band gaps of ~1.2 to 2.4 eV Cu_2O oxide films are reported to have high transparency, with a slightly yellowish appearance and absorb usually at wavelengths below 600nm, whilst CuO absorbs strongly throughout the visible spectrum and is black in appearance [3].

II. EXPERIMENTAL DETAIL

The starting compound used in this study was copper (II) Acetate. The choice was made taking into account the fact that hydrolysis of acetate group gives products which are soluble in the solvent medium and get easily decomposed into volatile compounds under heat treatment [2]. A colloidal solution of copper acetate in ethanol was used as precursor. Copper acetate added to ethanol (10 g dm^{-3}) and again 1:1 ratio of monomethanolamine was added to the colloidal solution and stirred for 1 h. The resulting solution was sonicated for 2 h, kept overnight for stabilization [1] then obtained CuO film was filtered.The filtered solution was deposited on to a glass substrate by a single wafer spin processor. After setting the substrate on the substrate holder of the spin coater, the coating solution (approximately 0.2 ml) was dropped and spins speed on first step set for 500rpm for 10sec and increase spin speed to 3000 RPM for 60s and dried some time in room temperature. The procedure was repeated for preparation of Different samples and takes the different films which were annealed at different temperatures.

III. RESULT AND DISCUSSION

Variation of absorption co-efficient as a function of annealing temperature is displayed in figure 1. In addition to the annealing temperature, the absorption coefficient also depends on rpm speed, thickness of the film and molar concentrations. First let us see how variation in annealed temperature affects the absorption coefficient. It was observed that as annealing temperature was increased, the film thickness marginally decreases and eventually there was an increase in transmittance. Due to the increased transmittance, absorbance gets reduced. Consider the first film which was annealed at 300^0C another sample is kept at 400^0C for 1 hour, and then samples were estimated under UV-visible spectroscopy and compared the result of both the samples. It is observed that as annealing temperature increased absorption peaks was decreased. But in this case all other parameters are kept constant. In the Second case fig (2) as we observed that rpm speed also changes absorption level again in this case also all other parameters are taken to be kept constant.

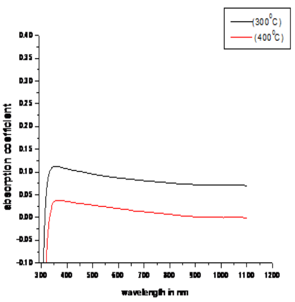


Fig 1

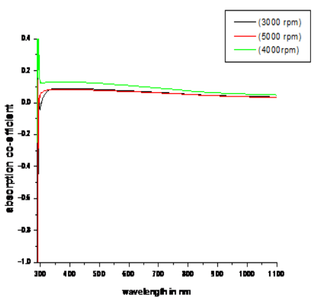


Fig 2

IV. EQUATION

The absorption co-efficient can be calculated using this relation

$$\alpha = 2.303A/t \qquad (1)$$

Where,'t' is the thickness of the film and 'A' is the absorbance.

The Optical energy gap E_g and absorption coefficient α is related by the equation.

$$\alpha = (k/ h\nu)\,(h\nu - E_g)^{\beta} \qquad (2)$$

$$(h\nu\alpha)^{1/\beta} = h\nu - E_g \qquad (3)$$

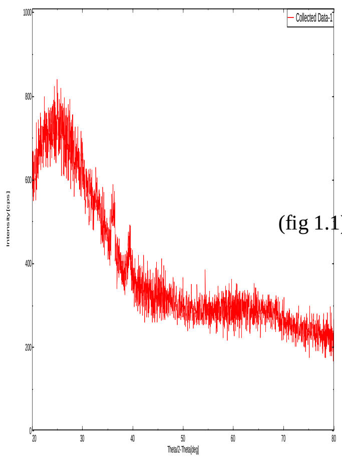
Where k = a constant, h = Planck's constant, hν = The incident photon energy and β is a number which characterizes the nature of electronic transition between valance band and conduction band, which can take the values 1/2, 3/2, 2 or more depending on whether the transition is direct –allowed ,direct-forbidden, indirect –allowed or indirect –forbidden. By inspection we have to decide for which plot of $(\alpha h\upsilon)^{1/\beta}$ as function of hυ yields a linear portion, so that which can intercept on the photon energy axis through straight line.

For CuO, direct allowed transitions β =1/2 yields a linear portion, so that which can intercept on the photon energy axis through straight line. So we can conclude that CuO is a direct band gap semiconductor. Therefore the formula is

$$\alpha = (k/h\nu)(h\nu - Eg)^{1/2} \qquad (4)$$

$$(h\nu\alpha)^2 = h\nu - Eg \qquad (5)$$

The graph was plotted $(h\nu\alpha)^2$ v/s *hν* and find energy band gaph.



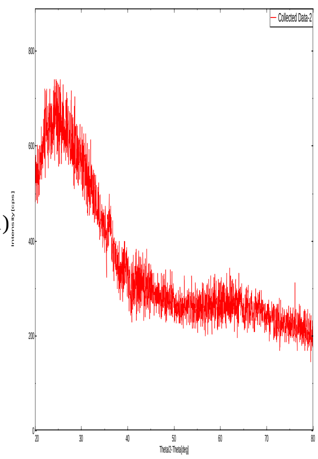


Fig 3 Fig 4

Structural properties in different annealed temperature

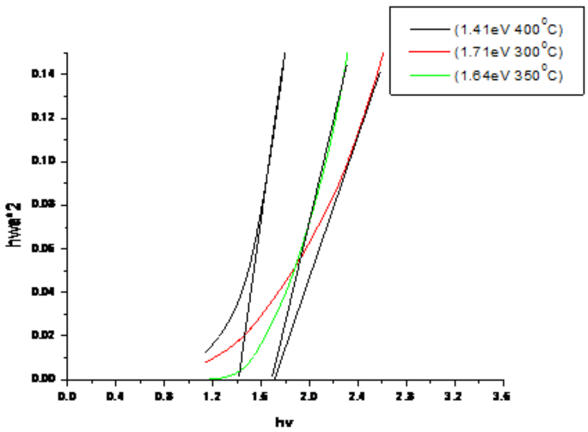


Fig 5

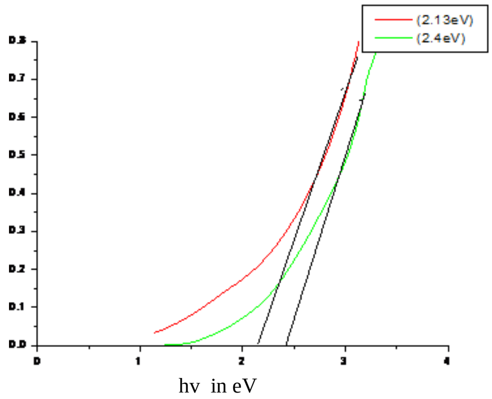


Fig 6

Fig 5 displays the variation of $(\alpha h\nu)^2$ versus hν. From the fig we can estimate that there is a variation in the band gap with annealing temperature. The decrease in the band gap energy is due to increase in the annealing temperature. In the graph, band gap of 1.41eV was observed for films annealed at 400^0C and for the films annealed at 300^0C the band gap energy was 1.71eV. From this graph we can predict that the band gap decreases with increase in the annealing temperature. There could be other factors which affect the band gap of CuO film such as concentration and number of layers. Band gap also varies by changing the rpm speed. As we know that annealed temperature increases band gap decreases but in fig 6 its shows reverse order. Optical band gap was measured without annealing temperature it showed 2.1eV, again when the same sample was annealed at 300^0C, then the energy band gap has 2.4eV because this type of result will occur only when the annealing temperature was not sufficient or oxygen atom to further oxidize the sample.

Table 1: estimation of band gap in different annealed temperature

Trial	*Annealed temperature*	*Estimated band Gap*
1	300^0C	1.71Ev
2	350^0C	1.64Ev
3	400^0C	1.41Ev

V. STRUCTURAL INVESTIGATION

X-ray diffraction was used to find the structural and characteristic of the deposited film. In XRD, we have set the scan range in the order 20^0-80^0 is the 2-theta value for the molar concentration of 0.1 in both the samples.

In above figure We have taken two samples, which was annealed at two different temperatures, one sample has annealed at 300^0C (fig 2.1) and another sample has annealed at 400^0c (fig 2.2) we got amorphous structural film. This type results may occur due to the molar concentration and also in these XRD samples we were not using any stabilizer. Other possibility is annealed temperature not sufficient so far. These amorphous structural films also have some good applications. Amorphous films are used in transistor.in particularly it would be used as active layers in transistors.

VI. SURFACE ROUGHNESS BY AFM

An atomic force microscope (AFM) creates a highly magnified three dimensional image of a surface. The magnified image is generated by monitoring the motion of an atomically sharp probe as it is scanned across a surface. With the AFM it is possible to directly view features on a surface having a few nanometer-sized dimensions including single atoms and molecules on a Surface. This helps to directly visualize nanometer-sized objects and to measure the dimensions of the surface features (4) we have measured the surface roughness of the deposited film.

The figure (3.1) shown below it shows the surface roughness of about 0.0193 micro meter, which was annealed at 300^0C. Then we consider the second case this film which was annealed at 400^0C it shows the surface roughness of about 0.0163 micro meters (fig3.2). As compare results to both the film it clears that grain size will decreases has increasing the temperature. If grain size decreased means transmittance is more suppose in absence of absorbance CuO has a wide band gap nature material it is inability to absorbs in visible region[5]

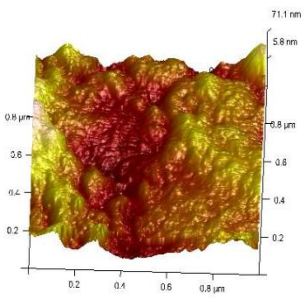


Fig 7

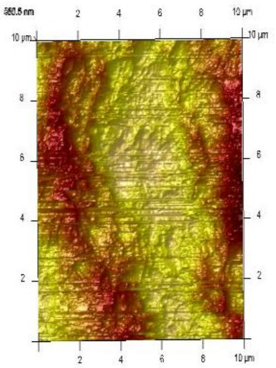


Fig 8

VII. CONCLUSION

In this study CuO film was prepared with different concentration and physical properties were studied using XRD, AFM and optical properties studied by UV spectrometer. Band gap and absorption co-efficient were calculated at different annealing temperatures. We have also observed a variation of absorbance at different RPM speed. In this study, from the XRD result we have found that the films were amorphous in nature. Moreover, variation of grain size by changing annealing temperature was studied. These properties were useful in device application.

Appendix . A. Experimental Detail
B. Results And Discussion
C. Equation
D. *STRUCTURAL INVESTIGATION*
E. SURFACE ROUGHNESS BY AFM
F. CONCLUSION

VII. ACKNOWLEDGEMENT

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