# ANALYSIS AND SURVEY ON JNS DEPOSITED PURE AND AI DOPED CUO THIN FILMS

1. Dr.R. MAHENDRAN, Assistant professor of Electronics
Government Arts College
Kulithalai.

2. Dr.P. Venkateswari
HOD of Electronics , RVS College of Arts and Science
Coimbatore .

3.Dr S.RAVIKUMAR
HOD OF ELECTRONICS
SENGUNTHAR ARTS AND SCIENCE COLEGE
TIRUCHENGODU..

## Abstract

The present work delineates the streamlining of substrate temperature, mole fixation and volume of the arrangement of copper oxide (CuO) thin films arranged by jet nebulizer spray pyrolysis (JNSP) method. Such arranged CuO films were streamlined and portrayed by XRD, SEM, EDX, UV–vis and I–V. From XRD examination the mole fixation, volume level and substrate temperature of the readied CuO films were fixed as 0.20 M, 5 ml and 450 ◦C separately and upgraded for P–N diode application. The resistivity of films was improved by performing isochronal and isothermal examinations on films, by strengthening in air at various timings of 15-120 min and temperature in the range from 100 - 400 ºC, separately. Films found to have resistivities in the scope of $1.33\times10^{-2}$ - $1.214\times10^{-2}$ Ωcm. The capacitance as an element of recurrence on the intersection affirms the presence of enormous interface conditions of $5.752\times10^{10}$ Fcm-2eV$^{-1}$ because of a lot of stick openings inside the sprayed films. This paper dissected and study on the different sorts in the SnO2 and its portrayal of procedure levels.

**Keywords:** Thin Films, Doped, Gas Sensor, Optical, Morpological.

## 1. Introduction

Lately researchers have made quick and noteworthy advances in the field of semiconductor material science. A standout amongst the most significant fields of current enthusiasm for materials science is the crucial perspectives and uses of metal oxide thin films. The trademark properties of such coatings are low electrical resistivity and high straightforwardness in the noticeable district. The innovative enthusiasm for the investigation of metal oxide semiconducting films was created basically because of the potential uses of these materials both in industry and research. However, cost viability and the shortage of the material made the trouble in acquiring ease metal oxide coatings. Subsequently the minimal effort high productivity metal oxide materials has been a theme of dynamic research throughout the previous couple of decades. This brought about the advancement of parallel materials like

ZnO, SnO2, CdO, CuO and ternary materials like Zn2SnO4, CdSb2O6:Y, GaInO3etc. The utilization of multi segment oxide materials makes it conceivable to have metal oxide thin films reasonable for particular applications as by modifying the substance creation, one can control the electrical, optical, synthetic and physical properties of these films. In any case, the upsides of utilizing parallel materials are the effortlessness to control the synthetic arrangements by fluctuating the affidavits conditions. In such manner, CuO films created in 1980s, are exceptionally helpful as these utilization Cu, an inexhaustible, modest and nontoxic material. Resistivity of this material is as yet not extremely low, yet can be decreased through doping with certain components like Cd, Gd, Ni, Mn, Zn and Fe. Henceforth there is an incredible enthusiasm for CuO as a minimal effort blend metal oxide film. Another bit of leeway of this sort of doping was that the auxiliary, morphological and optical properties of the film were somewhat influenced by the different metals consolidation. Fig. 1 demonstrates the cross area of CuO/n-Si sun powered cell. Hetero-intersection sun based cells were created utilizing the design Au/CuO/nSi/Al.

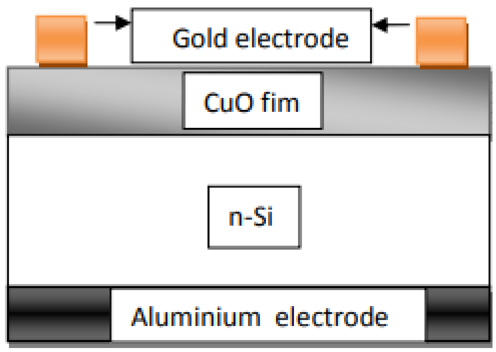


**Figure 1: Cross-section of p-CuO/n-Si hetero-junction solar cell**

Anthropogenic ecological contamination and inadvertent spillages of dangerous or unstable gases has prompted an earnest interest for important gas sensors for distinguishing unsafe gases in air. A nitric oxide or nitrogen monoxide (NO) gas sensor is tremendously required on the grounds that NO gas is firmly associated with human life. As a result of ongoing concentrated investigations of NO gas sensors, a few kinds of NO gas sensors have been proposed. The most down to earth and viable are of the oxide semiconductor type, which uses oxide semiconductors including ZnO and CuO as the gas detecting component. In any case, most oxide semiconductor-based gas sensors require activity at moderately high temperatures and have modest delicate reactions. Late advancements in the combination of ZnO and CuO nanostructures with controllable size and shape have given a decent chance to improve gas detecting execution on account of their enormous surface-to volume proportion. Specifically, a critical upgrade in the gas detecting properties of gas sensors dependent on ZnO nanorods has been accounted for. In the interim, oxide semiconductor p–n hetero intersection structures have been viewed as a key innovation in numerous electronic and optoelectronic gadgets including gas sensors. Photovoltaic gadget which changes over sun based light into electrical vitality is most reasonable for the creation of helpful and ease vitality. In any case, serious issue here is the advancement of effectively accessible and eco benevolent safeguards that can give sensibly high proficiency cells. Finding less expensive material and a basic procedure turns into the viable method to diminish the expense. Hence, the minimal effort sun oriented cells have increased more consideration as of late. One of the great hopefuls is hetero intersection sun powered cells shaped essentially by saving straightforward semiconductor films, for example, CuO on Si substrates. The hetero intersection sun oriented cells have various potential preferences, for example, a brilliant blue reaction, basic handling steps and low preparing temperatures. CuO films are favored over ITO because of lower cost and inexhaustible asset of copper on the earth. A few systems have been utilized for the planning of CuO thin films, which incorporate sputtering, concoction vapor statement, sub-atomic shaft epitaxy and spray pyrolysis. Most likely, the spray pyrolysis is the least expensive and rich procedure towards readiness of thin films. In this view, investigation of CuO films with moderate band hole, great electrical and optical properties, less poisonous quality, ease and lower affidavit temperature, is picked as a potential possibility for sunlight based cell applications. The films arranged by Spray pyrolysis are of better crystalline quality, perfect, disciple, having higher thickness and lower porosity and so forth., which are great characters for sun based cell and sensors. It needs no vacuum in light of the fact that the films are stored in the air feeling. Numerous works focus on vigorously doped CuO for its potential use as sun oriented cell safeguard. CuO can be utilized as sun based cells safeguard layer as well as hetero-intersection accomplice. CuO/Si intersection has a basic structure and a brilliant photovoltaic (PV) gadget.

## 2. SnO2 Types

### 2.1 SnO/SnO2 Diode Device Characteristics

To exhibit the appropriateness of the SnO thin film just as to further affirm its p-type conduction, a straightforward p-n junction diode was created. The thickness of the p-and n-layer assumes a noteworthy job in the determination of diode attributes. As we are setting up the p-and n-type from same material and insignificant oxidation state assumes job in the kind of conduction, the proper thickness must be picked. It is outstanding that the conductivity of the n-SnO2 layer is for the most part because of the oxygen inadequacy where as in SnO, the overabundance oxygen is in charge of prompting p-type conductivity. The p-type layer was stored with a shadow cover. The SnO (100 nm) was saved on the SnO2 (200 nm) layer under oxygen surrounding, which may result in a thin blended characteristic layer between n-$SnO_2$ and p-SnO as portrayed from the TEM picture. In the first place, this gadget obviously shows redressing conduct, with a run of the mill forward-to-turn around current proportion in the scope of - 10 to 10 V. This p-n junction has next to no arrangement obstruction, since everywhere forward voltages in the incline of the I-V bend is huge. A little arrangement opposition is normal for this p-n hetero junction since both metal contacts are ohmic with unimportant contact obstruction. It is outstanding that the electron diffusion from the n-side is dictated by the acceptor concentration ($N_A$) of the p-side, and is free of its own doping level ($N_D$). For this, the acceptor concentration must be more, which can be accomplished by increment in thickness. The spillage current under invert inclination is exceptionally low, and the forward limit voltage is 3.5 V. As a homo junction, the p-SnO/n-SnO2 diode has potential preferences over hetero junction diode on account of less interface imperfection issues.

## 2.2 SnO2 Thin Film Gas Sensor For Ethanol

In the course of recent decades, tin oxide based films are broadly utilized as gas sensors because of their high affectability within the sight of limited quantities of certain gases of intrigue viz. carbon monoxide, ethanol, methane and so on. Associated to this preferred position is the straightforward structure, heartiness, quick reaction and the likelihood of miniaturization of these gadgets. Ethanol vapor sensors have been broadly utilized in a wide scope of regions, for example, compound, biomedical, and sustenance ventures, wine-quality checking, and breath examination. In the ongoing past, SnO2 is recognized as one of the promising metal oxide materials for gas detecting because of its one of a kind electrical and electronic properties in addition to its cost adequacy. Semiconducting metal oxides are every now and again utilized as liquor sensor materials since they act as 'chemiresistors' where the reactant oxidation of the liquor by the semiconducting metal oxide influences the material's electrical conductivity. There are not many reports on room temperature detecting of various gasses and unpredictable natural mixes by SnO2 yet their detecting reaction isn't sufficiently high. So as to defeat the issue, the material modifications because of irradiation are normal. It is fascinating to perceive how these modifications have impacted the sensor's reaction. Numerous creators have utilized Swift Heavy Ion (SHI) irradiation adequately to alter the structure of the materials. These progressions happen, gave that the vitality misfortune along the way is more noteworthy than a limit estimation of electronic vitality misfortune (Se). The spatial distribution of this vitality deposition emphatically relies upon the ion speed as the speed diminishes along its direction the vitality thickness kept close to the way increments. As indicated by the warm spike model, the shot vitality misfortune causes high neighborhood temperature rise which may prompt material modification by means of electron-phonon coupling.

## 2.3 Zn doped CuO (Zn:CuO) thin films

The Zn doped CuO (Zn:CuO) thin film are readied utilizing different zinc sulfate (ZnSO4) concentrations, for example, 0.20, 0.40, 0.60 and 0.80 mM utilizing potentiostatic mode. The impact of ZnSO4 concentration on thickness, auxiliary, morphological, compositional and optical properties of Zn doped CuO (Zn:CuO) thin films are examined. For this situation, the solution pH, deposition potential, shower temperature and deposition time are fixed as 11±0.1, - 650 mV versus SCE, 75oC and 30 minutes, individually. The concentration of CuSO4 and tartaric corrosive are additionally fixed as 30 mM.

### 2.3.1 Thickness and structural

The Mn:CuO film thickness is assessed against different MnSO4 concentrations going from 0.5 to 0.20 mM. The quicker development rate is 33.66 nm/min for Mn:CuO thin film arranged at 0.05 mM MnSO4. The lower estimation of thickness is seen at 810 nm for 0.20 mM GdSO4 concentration. The auxiliary properties are considered utilizing X-beam diffraction designs for Mn doped CuO thin films arranged at different doping concentrations. The polycrystalline idea of Mn:CuO thin films, whose c-hub was specially situated typical to the substrate. Henceforth, the different covering or the heaping up of each film was considered not to irritate the general development of the films with c-hub orientation. From this figure the overwhelming orientation of the film is and its relating Bragg‟s point 36.34o. The pinnacle forces are increments with increment of doping molar concentration of manganese sulfate for Mn:CuO thin films. The overwhelming orientation of 0.20 mM arranged Mn:CuO thin film has seen in (- 111) grid orientation. This may because of the high substance Mn incorporation in CuO.

### 2.3.2 Morphological and compositional

The surface morphology of Mn doped CuO thin films were inspected by SEM. The pyramid and cuboid formed grains are watched for Mn:CuO thin films. Additionally progressively number of pyramid formed grains is agglomerated to one another. This may because of the Mn molecules are expanded weight on the outside of the film. It is seen from the examining electron micrograph of Mn doped CuO film normal grain estimate around 300 nm. The 0.10 mM concentration of Mn doped CuO films have seemed, by all accounts, to be bigger grains are scattered in littler grains and displayed different sizes of grain. The sizes of the grains are assessed in the scope of 150 – 200 nm. The littler roundly and cuboid molded grains are displayed for Mn:CuO thin film arranged at 0.15 mM MnSO4. The grain limits couldn't watched well in this doping concentration arranged Mn:CuO thin film. The smooth surface saw with nano-level grains of SEM micrograph for Mn:CuO thin film arranged at 0.20 mM manganese sulfate. The outside of the film canvassed with nano-layer in SEM micrograph. This outcome is an expansion in nucleation over-development and the stores are increasingly conservative with uniform grain structure in higher Mn content incorporation of CuO lattice.

### 2.3.3 Optical

The transmission spectra were recorded at room temperature in air to acquire information on the optical properties of the Mn doped cupric oxide thin films. The optical transmission spectra of Mn:CuO thin films kept onto glass substrate at various MnSO4 concentrations. The wavelength comparing to beginning of obvious transmission increments with MnSO4 concentrations. The impact of MnSO4 concentrations on the transmission of Mn:CuO thin films might be related with the variations in the film thickness, auxiliary properties, surface smoothness, imperfection thickness and concoction nature of the films. The nearness of surface plasmons reverberation affirms that the crystallite sizes are in the nanometer routine. The expansion in the transmittance is may likewise be related with the variations in the accessible transporter concentration. The optical parameters, for example, absorption coefficient and band hole are resolved from optical absorption estimations.

### 2.4 Ni doped CuO (Ni:CuO) thin films

The Ni doped CuO (Ni:CuO) thin films are set up at different nickel sulfate (NiSO4) concentrations, for example, 0.10, 0.30 and 0.50 mM utilizing potentiostatic mode. The impact of NiSO4 concentration on thickness, basic, morphological, compositional and optical properties of Ni:CuO thin films are explored. For this situation, the solution pH, deposition potential, shower temperature and deposition time are fixed as 11±0.1, - 650 mV versus

SCE, 75oC and 30 minutes, separately. The concentration of CuSO4 and tartaric corrosive are additionally fixed as 30 mM.

### 2.5 Cd doped CuO (Cd:CuO) thin films

The Cd doped CuO (Cd:CuO) thin films are set up at different cadmium sulfate (CdSO4) concentrations, for example, 0.10, 0.20, 0.30 and 0.40 mM utilizing potentiostatic mode. The impact of CdSO4 concentration on thickness, auxiliary, morphological, compositional and optical properties of Cd:CuO thin films are researched. For this situation, the solution pH, deposition potential, shower temperature and deposition time are fixed as 11±0.1, -650 mV versus SCE, 75oC and 30 minutes, separately. The concentration of CuSO4 and tartaric corrosive are likewise fixed as 30 mM.

### 2.6 Optical parameters evaluation of metal doped CuO thin films

The optical parameters of metals doped CuO thin films were evaluated for films developed utilizing higher concentration of each metal doped condition and are talked about in this section. The higher concentration Zn:CuO, Fe:CuO, Mn:CuO, Ni:CuO, Cd:CuO and Gd:CuO thin films are set up at 0.8 mM, 0.2 mM, 0.2 mM, 0.5 mM, 0.4 mM and 0.4 mM, individually. Wemple and Di-Domenico utilize a solitary oscillator description of the recurrence subordinate dielectric steady to characterize "dispersion vitality" parameters „Ed"and „E0". The model can be connected to the refractive file dispersion estimation for our framework under as higher concentration metals doped conditions. The dispersion assumes a significant job in the examination for optical materials, since it is a huge factor in optical communication and in planning gadgets for otherworldly dispersion. In spite of the fact that these guidelines are very unique in detail and iconicity impact the refractive list conduct of solids in manners that can be essentially portrayed. Wemple and Di-Domenico have examined various solids and fluids utilizing a solitary powerful oscillator attack of the structure. The model depicts dielectric reaction for transitions underneath the optical hole esteems. The ghastly reliance of refractive list in semiconductors can be assessed utilizing the single oscillator model proposed by Wemple and Di-Domenico and furthermore these models have been broadly examined in ongoing year.

### 2.7 Photoluminescence and resistivity studies

The commonplace room-temperature photoluminescence (PL) spectra of the different metals doped CuO thin films arranged at higher concentration of metal sulfate source as clarified above section. The range demonstrates a solitary radiance band in the room-temperature PL range of the metal CuO film, i.e., the noticeable emission crest at ~ 500nm. Curiously, it is seen that, in all cases, the noticeable emission is more grounded. The purpose behind the emission crest at 500 nm is simply the nearness absorption impact and non radiative recombination of semiconductor which may diminish the external quantum yield proportion of metals doped CuO semiconductor. The emission top at 500 nm has been related with free exit on radiative recombination of an electron and a gap.

## Conclusion

A concise introduction about metal doping on semiconductor thin films is displayed trailed by the trial methodology of union of metal doped cupric oxide thin films. A few metals, for example, Ni, Cd, Gd, Fe, Mn and Zn are doped with different doping molar concentrations to shape metal doped CuO thin films. Thickness of the different metal doped CuO films are assessed in the scope of 700 to 1200 nm by surface profilometer. The basic confirmation of different metals doped cupric oxide thin films are examined by X-beam diffraction designs. Microstructural properties of metal doped cupric oxide thin films as a function of doping concentration are exhibited utilizing X-beam line profiles. The compositions of electroplated metal doped cupric oxide thin films are assessed utilizing vitality dispersive examination by X-beams (EDX). The nuclear rates of oxygen are seen to diminish with increment of doping concentrations while nuclear level of metals in the films increments with the expansion in doping concentration in the electrolyte.

## References:

[1] B. Purusottam Reddy, K. Sivajee Ganesh, O.M. Hussain, Growth, microstructure and super capacitive performance of copper oxide thin films prepared by RF magnetron sputtering, Appl. Phys. A 122 (128) (2016) 1–10.

[2] M.L. Zeggar, F. Bourfaa, A. Adjimi, M.S. Aida, N. Attaf, Copper oxide thin films for ethanol sensing, IOP Conf. Ser.: Mater. Sci. Eng. 108 (2016) 1–5, 012004.

[3] T.J. Richardson, J.L. Slack, M.D. Rubin, Electrochromism in copper oxide thin films, Electrochim. Acta 46 (2001) 2281–2284.

[4] H. Kidowaki, T. Oku, T. Akiyama, Fabrication and characterization of CuO/ZnO solar cells, J. Phys. Conf. Ser. 352 (2012) 1–5, 012022.

[5] E.O. Omayio, P.M. Karimi, W.K. Njoroge, F.K. Mugwanga, Current–voltage characteristics of p-CuO/n-ZnO:Sn solar cell, Int. J. Thin Film Sci. Technol. 2 (2013) 25–28.

[6] X. Zhang, J. Song, J. Jiao, X. Mei, Preparation and photocatalytic activity of cuprous oxides, Solid State Sci. 12 (2010) 1215–1219.

[7] M.R. Johan, M.S.M. Suan, N.L. Hawari, H.A. Ching, Annealing effects on the properties of copper oxide thin films prepared by chemical deposition, Int. J. Electrochem. Sci. 6 (2011) 6094–6104.

[8] N. Serin, T. Serin, S. Horzum, Y. Celik, Annealing effects on the properties of copper oxide thin films prepared by chemical deposition, Semicond. Sci. Technol. 20 (2005) 398–401.

[9] W. Siripala, A. Ivanovskaya, T.F. Jaramillo, S.H. Baeck, E.W. McFarland, A Cu2O/TiO2 heterojunction thin film cathode for photoelectrocatalysis, Sol. Energy Mater. Sol. Cells 77 (2003) 229–237.

[10] H. Yang, J. Ouyang, A. Tang, Y. Xiao, X. Li, X. Dong, Y. Yu, Electrochemical synthesis and photocatalytic property of cuprous oxide nanoparticles, Mater. Res. Bull. 41 (2006) 1310–1318.

[11] B.J. Wood, H. Wise, R.S. Yolles, Selectivity and stoichiometry of copper oxide in propylene oxidation, J. Catal. 15 (1969) 355–362.

[12] J. Li, L. Liu, Y. Yu, Y. Tang, H. Li, F. Du, Preparation of highly photocatalytic active nano-size TiO2–Cu2O particle composites with a novel electrochemical method, Electrochem. Commun. 6 (2004) 940–943.

[13] F.A. Akgul, G. Akgul, N. Yildirim, H.E. Unalan, R. Turan, Influence of thermal annealing on microstructural, morphological, optical properties and surface electronic structure of copper oxide thin films, Mater. Chem. Phys. 147 (2014) 987–995.

[14] M.L. Zeggar, L. Chabane, M.S. Aida, N. Attaf, N. Zebbar, Solution flow rate influence on properties of copper oxide thin films deposited by ultrasonic spray pyrolysis, Mater. Sci. Semicond. Process. 30 (2015) 645–650.