# Ethanol Sensor using Cu doped ZnO Thin Film

*Sounder.J[1], P.Gowthaman[2]*
*[1]Ph.D Research Scholar, Thin film Research Centre, Erode Arts and Science College, Erode*
*[2]Assistant professor, Thin film Research Centre, Erode Arts and Science College, Erode*
*Corresponding author's E-mail: sounderj08@gmail.com*

***Abstract :** Ethanol sensing characteristics of Cu doped Zinc Oxide thin films prepared by sol-gel dip coating method were reported in this article. The sol for dip coating was synthesized using Zinc acetate dehydrate (Zn ($CH_3COO2$).$_2$HO) and organic polymer sodium carboxy methyl cellulose (Na- CMC) as a starting material. Crystallite size was characterized by X-ray diffraction (XRD) and the morphology was studied using field Emission Scanning Electron Microscopy (FESEM). The gas sensing characteristics was studied using chemiresistive method. And the Gas sensing parameters such us response time/recovery time, best lowest detection limit, of the thin film towards Ethanol were also highlighted.*
***Keywords:** ZnO, Na-CMC, sol-gel dip coating, thin film, Ethanol sensor.*

## I.INTRODUCTION

ZnO gas sensors have been intensively investigated recently, and films have been fabricated in a variety of structures, including as single crystals, thick/thin amorphous films, nano rod arrays, and nano tube assemblies [1–4]. The general gas sensing mechanism underlying metal oxide sensor function involves a resistance change through a reaction between the oxygen species (O−2, O2−2, O2−) chemisorbed onto the metal oxide surface and the target gas molecules. Under ambient air conditions, the surface of a metal oxide material is covered with charged oxygen species that accept charge carriers (electrons) to form a depletion region on the surface.

As these species react with reducing agents, oxygen species are desorbed from the surface and release the trapped electrons, which reduce the film thickness in the depletion region and, consequently, the resistance. As the surface coverage of adsorbed oxygen species increases, the gas sensing response is expected to increase as well. Although the surface oxygen species density usually varies with the surface area, however, the main factors that affect the adsorption of oxygen species are the surface atomic structures related to the exposed facets and the surface defect densities, including zinc and oxygen vacancies [5, 6, and 7].

Gas sensors are generally classified as chemical or physical types based on their operational mechanism. Most of the conventional gas sensors are of the chemical type in which chemisorbed target gases on metal oxide [8-11], silicon [12] and carbon nano-tube (CNT [13, 14] substrates are quantified by the responses of their electrical [15] or optical property [16]. However, these types of sensors suffer from limited selectivity [15, 16] and difficulties in detecting gases with poor adsorption. Normally, a high working temperature is required to establish adsorption/desorption equilibrium. These nano materials have unique physical, chemical and optical properties, [17] which lead to its application in numerous fields. Nowadays use of nano materials in the field of gas sensor has gained interest as it helps in detection of toxic and combustible gases [18].

The excess of toxic and combustible gases cause degradation to environment and are hazardous to human health. Hence fabrication of gas sensor with good sensitivity, selectivity, quick response and recovery time to the lowest concentration of target gas together with low operating temperature is an art of interest.

From the various materials (metal oxides, organic compounds, polymers, metals) semiconducting metal oxide nano particles are extensively studied for gas sensing application due to small dimension, suitable operating temperature, more surface sites available for gas adsorption, high response towards many gases, low cost, portability, non-toxicity etc., [19,20].

## II. MATERIAL AND METHODS

The Researcher make a sol of 0.5mol concentration were prepared by dissolving the required essential amount of Zinc acetate dehydrate (Zn ($CH_3COO2$).$_2$HO) in to 20ml of iso-propanol it contain mono-ethanolamine(MEA) it perform as Thickening agent by the take the molar ratio of kept 1:1. Then the researcher prepared copper doping solution with same above process. 0.3mol of copper nitrate is dissolved in 100ml of di-ionized water and stirred both solution at the ratio of 1:3 Identical solution were stirred at 70°C for 1 hours to accelerate hydrolysis reaction and it obtained a white solution of sol-gel, which were used for coating after the room temperature and also aged 24hrs. The prepared the Cu- doped ZnO thin films for depositing sol on the glass substrate by using dip coating method at the time of 1min dip and 1min dry at the same time of 70°C and also repeated this process for 10 times . Finally allow to cool at room temperature and additionally it taken for various studies.

## III. RESULT AND DISCUSSION

The Researcher synthesized ZnO films were characterized by X-ray diffraction (XRD) and also characterized the scanning electron microscope (SEM) and sensor properties .At first the researcher shown the XRD spectra.

***X-Ray spectrum for prepared ZnO***

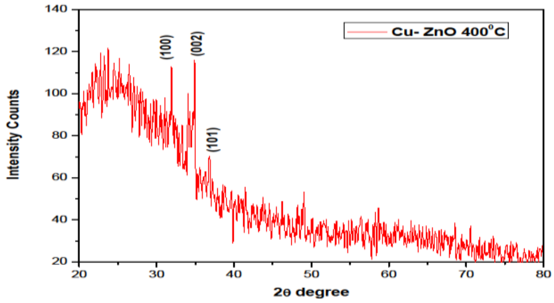


Fig-1 XRD Pattern of Cu doped ZnO 400°C

The XRD pattern shows the most prominent peak observed the detection (h l k) peaks are at 2θ values of 31.96°, 34.84° and 36.73° corresponding to (101) plane other planes corresponding to (100),(002),(101), are also observed with low relative intensities. The detection peak respectively according, to JCPDF card No. 036 1415. The particle sizes have range of 4.35 nm. The nano-particle sized was calculated using Debye Scherrer's formula.

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

FE-SEM Analysis

The Researcher is also shown that the FE-SEM image of prepared thin film as shown below figure. Researcher says that the FE-SEM studies were clearly shown in prepared ZnO film exhibits good morphology and the researcher prepared the Cu-doped ZnO film by a simple dip coating method is more effective and also useful for researcher research.

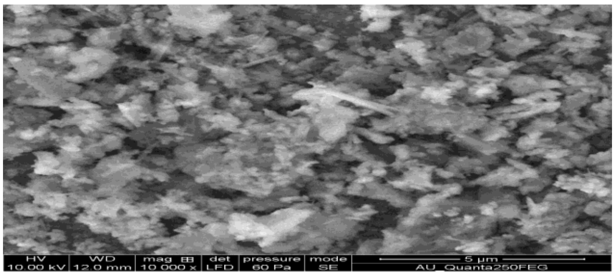


Fig-2 FE-SEM image for Cu doped ZnO 400°C

FE-SEM image of Cu doped ZnO thin film annealed at 400°C. The image shows the structure contains the cluster of nano particles were grown in all directions. It is bealieved that the annealing temperature causes film crystallization and reamoval of organic residue from the deposited film.

**Electrical Properties**

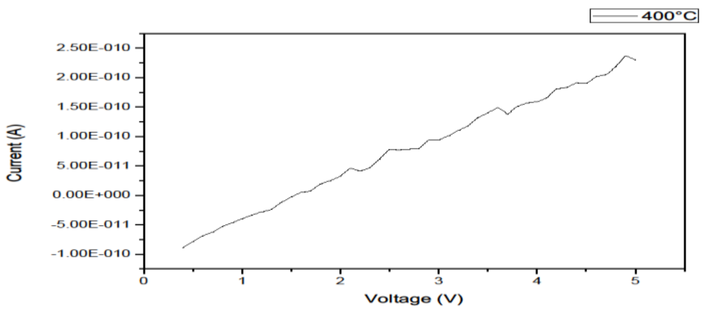


Fig-3 Electrical properties for Cu doped ZnO 400°C

The Cu doped ZnO annealed at 400°c, shows a sharp increase in current from -100E-10 to current 2.50E-010, with a given voltage from 0 to 5v. For electrical properties when the voltage is increase current also get increase due to in conducting properties, so when the film is suitable for gas sensing applications.

**Resistivity**

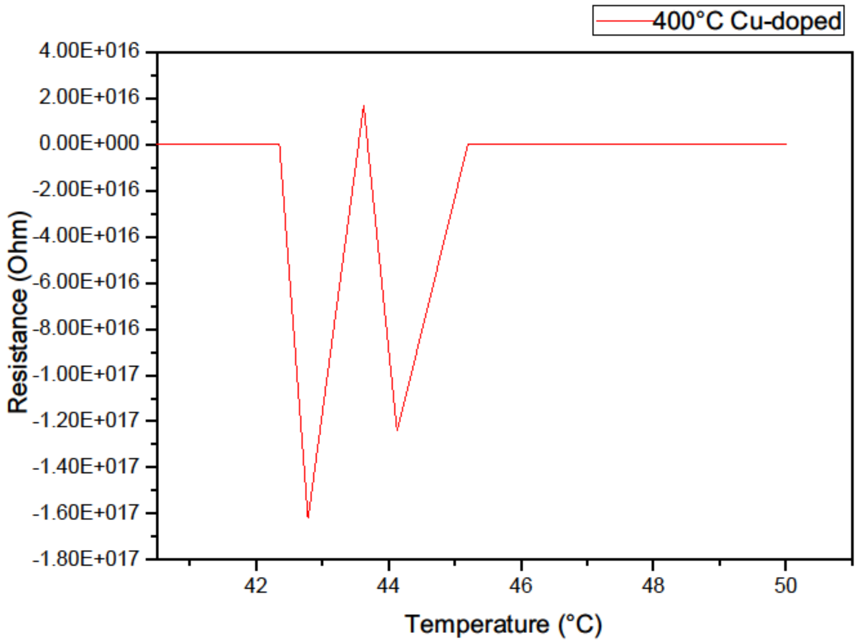


Fig-4 XRD Resistivity for Cu doped ZnO 400°C

For Cu doped ZnO 400°c in region I, the resistivity of the sample is observed sharply decreasing with temperature to ~43°c. The sample exhibit Negative terminal co efficient region character in this region. On further heating the resistivity of the sample is start increasing with maximum resistivity of $1.5x10^{1}$ M Ωm at around 43.5°c in region II. The change in resistivity is observed from $1.5x10^{-1}$ M Ωm x to $1.5x10^{1}$ M Ωm and exhibits positive terminal co efficient region behavior. In region III, an decreased in resistivity, with a increased in temperature with the present experimental range from $1.5x10^{1}$ M Ωm to $1.5x10^{-1}$. For resistivity properties, when the film is act as a resistor, so when the temperature is increases the resistivity get decreases, so it confirm that the film have good resistivity properties.

**GAS Sensor**

The sensor test was done by closed chamber at room temperature. The Cu-doped ZnO thin film can act as Ethanol Gas sensor for an selectivity of constant values. The limit of room temperature lower detection of ZnO thin film observed to 10 ppm of Ethanol with the response of 13s. The researcher main result of gas sensor has been shown in the sensed the gas, that the below tabulation has been verified that is response to sensing material given below

**Tabulation of Gas Sensor**

| **Prec** | **CVD Method** | **Tdep $^{0}$C** | **Form** | **Features nm** | **Sensor type** | **Top $^{0}$C** | **Ppm** | **gas** | **R** |
|---|---|---|---|---|---|---|---|---|---|
| **400$^{0}$c** | CVD | 570 | Film | 60L | Ω + 0 SNO | 390 | 10 | ethanol | **13s** |

Prec - precursors,
Tdep - temperature of deposition,
Top: operating temperature,
tres: response time,
ppm: partsper millon,
R = Ra/Rg (oxidative gas),
R = Rg/Ra (reductive gas).

## IV. CONCLUSION

The simple dip coating for Cu doped ZnO Nano rods with gas sensor method and its gas sensing characteristics were studied. The most stable cluster of nano particles structures was confirmed by XRD. Researcher is also done the gas sensor test by the closed chamber at room temperature. The gas sensor tests shown that the Cu-doped ZnO Thin film can act as an ethanol sensor from constant values. Hence the Researcher has finally concluded that it has identified diabetes.

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