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# Synthesis and Characterization of Zinc Oxide thin film as $H_2S$ Gas Sensor

[1]Shazia Umar, [2] Bhuwan Bhasker Srivastava [3]Susheel kumar Singh & [4]Shad Husain

*[2,4]Department of Physics, University of Lucknow, Lucknow-226007*
*[2&4]Associate Professor, Department of Physics, Shia P.G. College, Lucknow*

**Abstract:**
*The zinc oxide thin film have been synthesized and studied as the sensing element for the detection of $H_2S$ gas. The zinc oxide thin films were synthesized by dip-coating method. Gas sensing properties of zinc oxide thin films were studied for $H_2S$, LPG and NH3 gases by changing the concentration of test gases. The prepared zinc oxide thin films can be used as promising material for semiconductor gas sensor for poisonous gases like $H_2S$ with high sensitivity. We report the conducting and transparent ZnO thin films fabricated by sol-gel dip - coating method. XRD, UV-VIS, SEM and PL are used to characterize these films. X- ray diffraction studies show that films are polycrystalline in nature and have hexagonal wurtzite structure. These films are found to show (002) preferential growth.*

***Keywords:*** *Zinc oxide; Thin film; Gas sensors; Dip coating; XRD; SEM*

## I. Introduction:

Dip-coating technique is used for the synthesis of zinc-oxide thin film, Dip coating is a very simple technique widely used for thin film deposition. Hydrogen sulphide ($H_2S$) is a toxic and inflammable gas, produced in sewage plants, coal mines and oil and natural gas industries [1].

It is used in large amounts in various chemical industries, research laboratories and as a process gas in the production of heavy water. It is required to detect $H_2S$ at these low levels. Spectral and fluorescence analysis [ 2,3] maybe used for detecting low concentrations of this gas but these sensors have high cost and large size. Semiconductor gas sensors have proved to be a low cost convenient option for monitoring of gas species and sensors in the form of thin or thick films, based on metal oxides like $SnO_2$, ZnO. Semiconductor gas sensors have proved to be a low cost and convenient option for monitoring of gas species and sensors in the form of thin or thick films, based on metal oxides like $SnO_2$, ZnO have been reported for detection of $H_2S$ gas [4, 5] in a ppm range.

Recently such sensors for low concentrations have also been reported [6, 7]. Zinc oxide (ZnO), with a wide band gap (3.4 eV) and a large excitation binding energy (60meV), has attracted remarkable attention for its electronic and photonic applications such as ultraviolet (UV)/blue light-emitting devices, It is used in Solar cells, piezoelectric devices, acousto- optical devices and chemical sensors [8]

and [9,10]. Nowadays, the development of gas sensors to detect volatile and toxic gases is imperative due to the concerns for environmental pollution and the safety requirements of industry and daily life. ZnO has been considered as a promising material of gas sensors because of its high electrochemical stability, non-toxicity, suitability to doping, and low cost. The sensing characters of a sensor depend on the shape and dimensionality of the sensing material a lot, so that multiplicate ZnO nanostructures have been synthesized as studied in the past decade. Undoped thin films were deposited by sol-gel Dip coating method. The technique is most suitable for the preparation of oxide films.

## II. Experimental Methods

Thin films were deposited by sol-gel Dip coating method. The technique is most suitable for the preparation of oxide films.. The films were deposited on glass substrates (microscope slides) by dip coating technique. The substrates were cleaned, before deposition, with freshly prepared chromic acid, followed by detergent solution and distilled water. The precursor solution used was of 0.1M concentration of high purity zinc acetate ($Zn(CH3COO)_2$) prepared in distilled water and stirred continuously for 1hour at room temperature. This solution is taken in a beaker and the pH was maintained around 8. Another beaker is filled with hot water at a temperature of 750°C.The cleaned glass plate was first dipped in Zinc acetate solution for fraction of seconds and then immersed in hot water solution. This process is repeated for 25 times and then immersed in hot water solution. This process is repeated for 25 times.

## III. Results And Discussion:

**XRD Technique:**

The XRD pattern of the sample shows that films are polycrystalline in nature showing the lattice planes (100),(101and(002) planes corresponds to that ZnO.

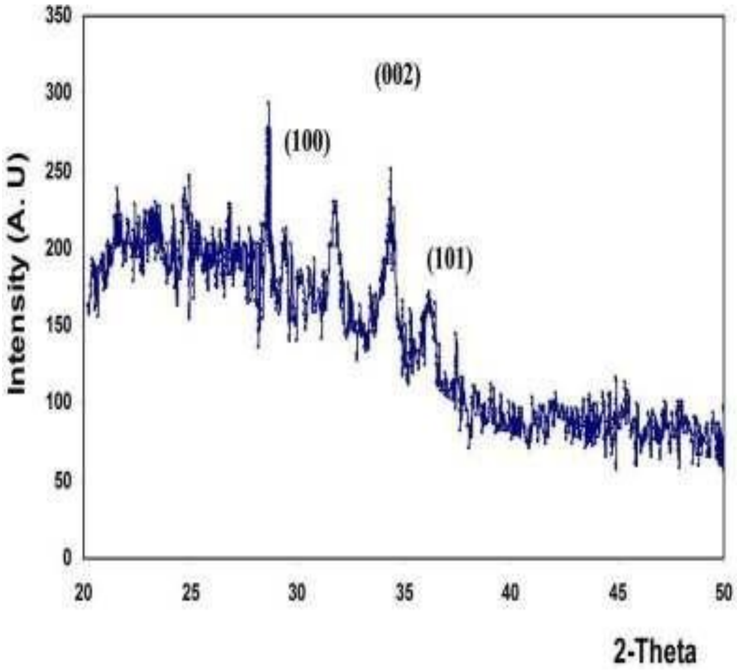


**Figure1: XRD of ZnO.**

**Scanning electron microscopy:**

The SEM micrograph of ZnO is shown in figure above which shows flake like structure all over the plane surface.Scanninng electron microscopy shows morphological structure of zinc oxide.

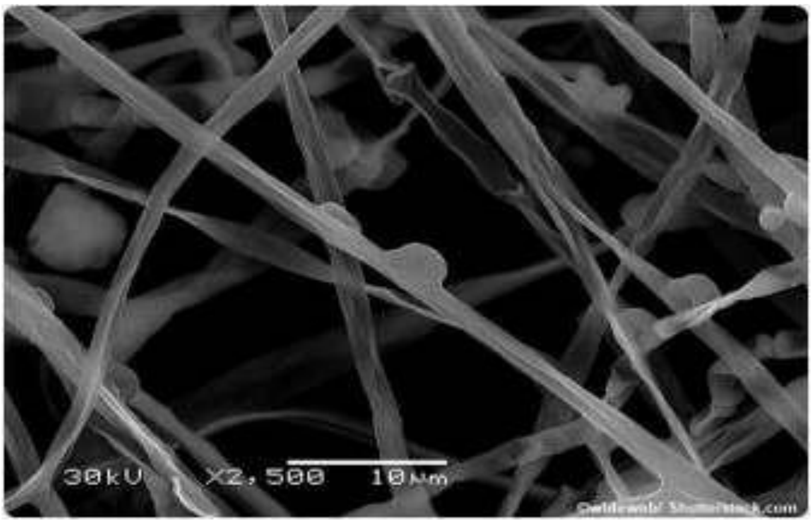


**Figure2**: SEM Micrograph ZnO.

**PL Spectroscopy:**
Photolumniscence spectra of pure ZnO thin films have been shown in figure 5 below. In PL spectrum a strong UV peak occurs at 395nmdue to free exciton transition with two visible peaks at 454nm and 487nm for pure ZnO.

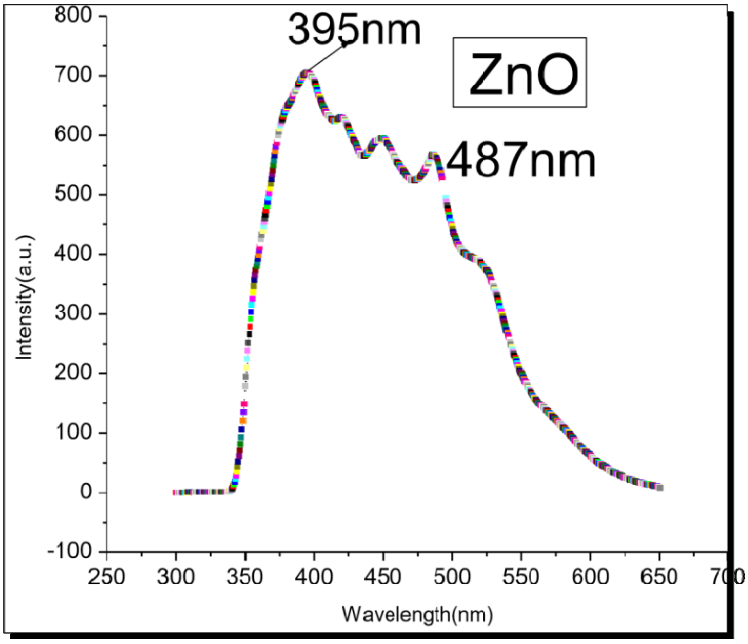


**Figure 4: PL spectroscopy of Zinc oxide**

**Gas-SensingStudies:**

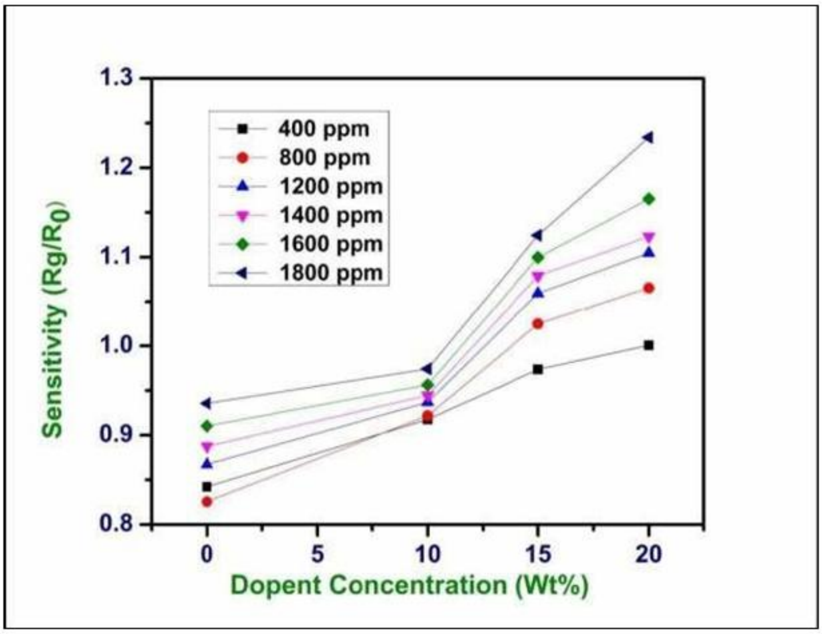


**Figure5: Gas sensing studies of ZnO**

The sensing properties of pure ZnO have been observed at room temperature ($28^0$C). It is found that the sensitivity variations with: (1) increase in $H_2S$ gas concentration for pure ZnO nano sensitivity gets increased.

## IV. Conclusion:

In this study, the structural, morphological, optical and gas sensing properties of ZnO thin film have been studied. The ZnO films are synthesized by simple dip coating method. The structural characterization of the filmsshowed hexagonal wurtzite structure.

synthesized by using zinc nitrate as precursor and sodium hydroxide as reducing agent was calculated from an absorption spectrum and is found to be 3.37 eV. This value matches exactly with the reported value. The thick films were prepared by screen printing method and thickness of films was observed in the range from 25µm to 35µm. The response of the nanocrystalline ZnO-based sensor was observed to be the largest to $H_2S$ gas.

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