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# Preparation of Nano Films from ZnO/MWCNT and Study their Applications as a Gas Sensor

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**Abstract:** Thin nanoparticles of zinc oxide were prepared using sol-gel. "The samples were prepared nano thin film (71 nm), various weight ratios were added from the MWCNT to the colloidal solution and at a rate of" "(0.423, 0.921, 1.624%). These solutions were deposited by using the spin coating technique on the glass substrate and interdigitated finger electrode. For the purpose of knowing the sensitivity and the extent of response of these samples to detect the different vapors of some toxic gases (ethanol, methanol, acetone and nitrogen). Nano thin film were prepared by using spin coting technique. The synthetic properties of these membranes were studied using X-ray diffraction.

**Key words:** ZnO, MWCNT, vapors, sensor, thickness, interdigitated

## INTRODUCTION

Zinc Oxide (ZnO) is at the forefront of semiconductor compounds II-VI with potential applications due to the high optical transmittance in the visible region due to its large band gap and electrical conductivity at room temperature; these characteristics make it an ideal candidate for applications such as transparent conductive electrode, window layers in the solar cell applications and gas sensors (Wang, 2004; Fan and Lu, 2005; Shinen, 2014). The nanoscale structure of zinc oxides plays an important role in the devices performance as an example in gas sensor devices because the large area will enhance the properties of gas sensors and moreover have safe biological properties (as a non-toxic substance) which makes ZnO very attractive for vital applications. The simple preparation methods of producing ZnO thin films give them the potential to be studied (Battez *et al*., 2008; Wu *et al*., 2009). ZnO can be applied as thin layers in transistor applications (Ohya *et al*., 2001) and is considered a rotational electronic material (Sharma *et al*., 2004). Zinc oxide films can be prepared using various techniques including lamination, chemical vapor, sol-gel and pyrolysis spray (Moustaghfir *et al*., 2003; Paraguay *et al*., 1999; Dinghua *et al*., 1998). Recently, due to its excellent physical properties and potential technological applications, ZnO has attracted considerable attention (Akkilic *et al*., 2012). ZnO is

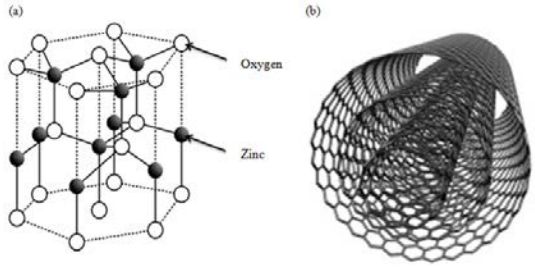


Fig. 1(a, b): Wurtzite structure of ZnO and (b) Multi-walled carbon nanotubes

an n-type semiconductor with wurtzite structure of hexagonal crystals (Jagadish and Pearton, 2007) as shown in Fig. 1a. O2-crystals can be described as tetrahedral and $Zn^2$+ ions consist of alternately flat, stacked (Pearton *et al*., 2005). On the other hand, carbon based materials such as Multi-Walled Carbon Nanotubes (MWCNTs) which has significant applications in the field of sensors as well as other electronic devices due to the large area; the MWCNT includes a plurality of tubes in a concentric cylinder as shown in Fig. 1b (Abdulridha, 2015; Dresselhaus *et al*., 2001); the number of concentric walls can range from 6-25 or more. The diameter of the MWCNT can be about 30 nm compared to 0.7-2.0 nm for a typical SWCNT. The unique properties of carbon nanotubes make it possible for a wide range of novel applications and existing performance improvements (Abdulridha,

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2015; Dresselhaus *et al*., 2001). Un-doped ZnO has high conductivity due to the crystalline defects that contribute to a number of secondary levels between the valence and conduction bands. On the other hand, doping ZnO is to improve the stability of ZnO and further increase the electrical conductivity as an example, doping with MWCNTs. Such thin film has high permeability in the visible region of the spectra and low resistance; the optical energy gap can be controlled by the concentration of doping material added to the ZnO (Jeong *et al*., 2007). The latter enhancement can be used in improving the characteristics of different applications such as solar cells, coatings and chemical sensor devices (Nishino *et al*., 1992; Mondal *et al*., 2008).

## MATERIALS AND METHODS

### Experimental section

**Sol-gel preparation of ZnO:** Firstly, 4 mL of isopropanol is placed on a stirrer following by adding 50 μL of Ethanolamine (MEA) under stirring for 30 min at 60°C to obtain the blending process of the solvents. Afterward, zinc acetate has been added to the solvent's mixture under stirring and the process was kept for 1 h at 60°C. The final solution was kept in a sealed beaker (using paraffin paper to prevent the penetration of dust and moisture into the colloidal solution) at room temperature for 24 h in laboratory conditions to obtain transparent and homogeneous viscous fluid.

**Preparation of sol-gel for the ZnO/MWCNT (doped zinc oxide):** Composite material based on mixing ZnO with MWCNTs has been carried out. After the preparation of sol-gel solution of pure ZnO, a specific amount of MWCNTs were added to the ZnO solution to obtain the final mixture. The ratios of mixing were about (0.423, 0.921, 1.624%) of MWCNTs in ZnO solution.

**Preparation of samples:** Clean glass slides were used after immersing them in ethanol for half an hour and then washed with distilled water three times after which the slides were placed in a thermocouple oven up to a degree 50°C for drying. Pure and MWCNTs-doped ZnO thin films were prepared using spin coatingmethod on pre-cleaned glass substrates. The solution is deposited on the sedimentation base during deposition. Then the sample is raised and placed on a hot plate at 60°oC until the solvent volatiles and the membrane dry. These samples are then placed in a furnace at 450°C.

## RESULTS AND DISCUSSION

**AFM images:** The results of the tests (AFM) of the nano films for pure (ZnO) and doped with different ratio of (MWCNTS) films which prepared by spin coating which showed a uniform granular surface morphology as in Fig. 2a-d. Where we note that the roughness increased with increasing the ratio of doped (Srinivas *et al*., 2012; Tokarsky *et al*., 2012).

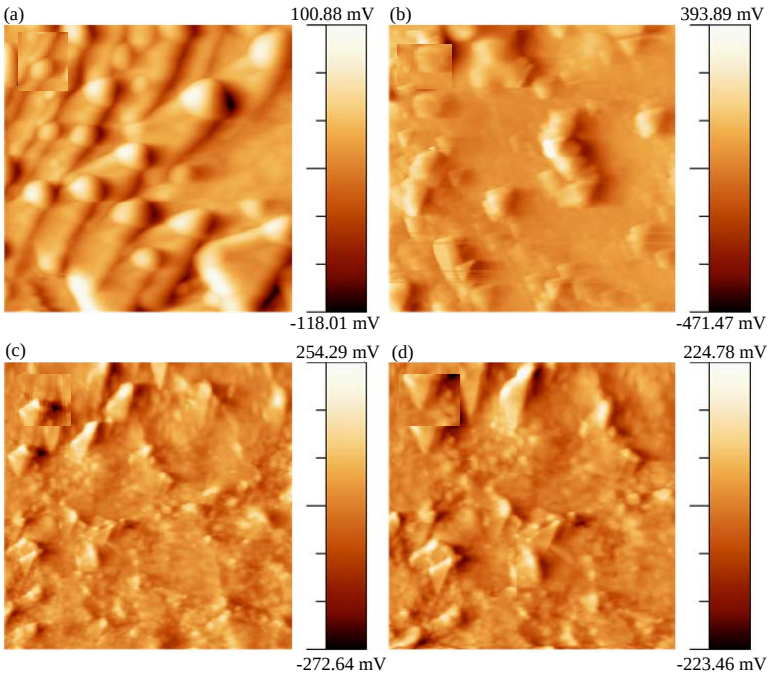


Fig. 2(a-d): AFM images for the ZnO based thin films, (a) pure, (b) 0.423% MWCNTs, (c) 0.921% MWCNTs and (d) 1.624% MWCNTs

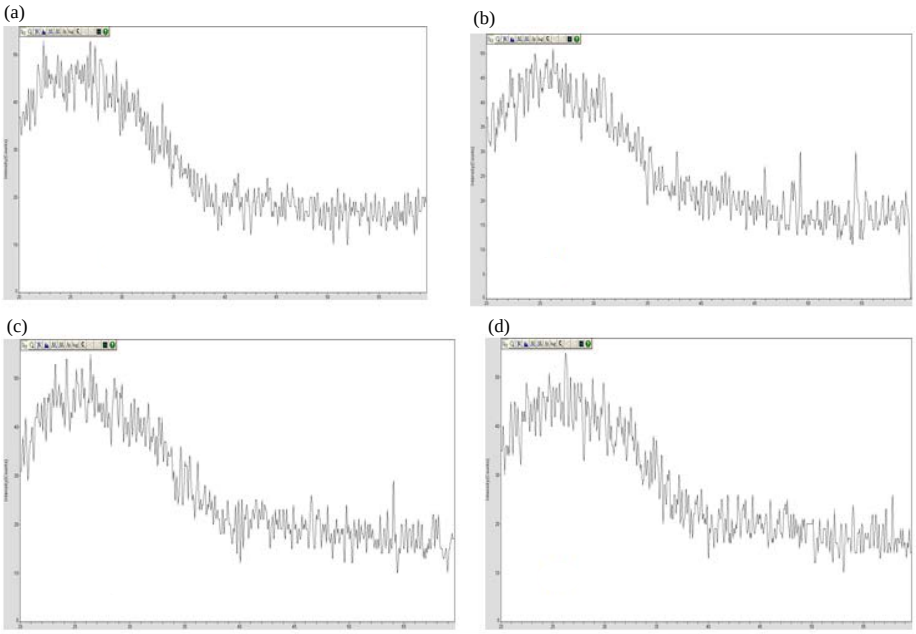


Fig. 3(a-d): XRD patterns for the ZnO based thin films, (a) pure, (b) 0.423% MWCNTs, (c) 0.921% MWCNTs and (d) 1.624% MWCNTs

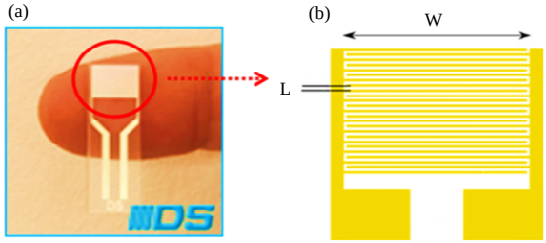


Fig. 4(a, b): Interdigitated electrodes used for the sensor

**XRD analysis:** ZnO membranes were examined with different fish (62, 71, 85) and at temperature (450°C) and ZnO/MWCNT$_s$ membranes with different deflection ratios, using X-ray diffraction (0.423, 0.921, 1.624%).

Figure 3a which represents the X-ray diffraction of pure ZnO, appears broad summit at (31, 32) while Fig. 3(b-d) represents X-ray diffraction of the ZnO doped by Carbon nanotubes with ratio 0.423% where notes the appearance of two peaks at (5-30°). An angle (5°) shows the diffraction for the parallel levels in the polymeric chain, an angle (30°) shows the diffraction of the levels orthogonal.

And Fig. 4 appear tested for the films with the ratio (0.921, 1.624%) where all films are show to have a random structure. These results are identical to the results of the researchers (Diaz-Sanchez *et al*., 2017; Chandra *et al*., 2017; Bhagwat *et al*., 2016).

**Sensor response:** The electrical conductivity was carried out using Interdigitated platinum Electrodes (IDEs) purchased from DropSens (Spain) (Fig. 4a and b). The IDE can be used to measure the surface conductivity (σ) of the samples from the following relationship (Kadem *et al*., 2015):

$$"\sigma = \frac{1}{V}\left(\frac{n}{WtL}\right)" \quad (1)$$

Where:

t : The thickness of the film (~100 nm)
W : The distance between the fingers (6.67mm)
n : The number of fingers (500)
L : The distance between electrodes (5μm)

Figure 5 shows that the sensitivity increases with the increased concentration of injected solutions when exposed to ammonia gas vapor and the amount of 20 μm in the beginning and in all cases and then open the air to volatilize the gas molecules and then increase the amount of vapor gas injected and all cases.

By observing the above shapes, the response of the thin film to the gas vapor is increased by increasing the rate of deflection. This explains our interpretation of the membrane through the image of AFM.

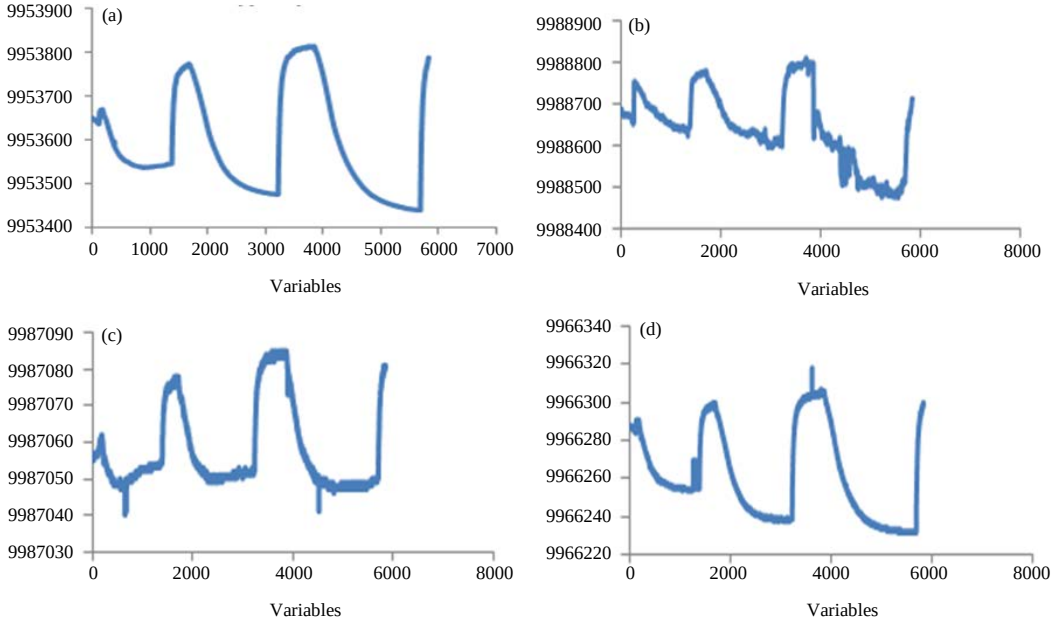


Fig. 5(a-d): Sensitivity of membranes to ammonia gas vapor, (a) ZnO (pure), (b) ZnO/MWCNT 1.624, (c) ZnO/MWCNT 0.921% and (d) ZnO/MWCNT 0.423%

## CONCLUSION

The results showed that the prepared membranes were crystallized and close to the standard values. Among the AFM samples, the surface roughness was increased, making it more sensitive. The ability of the response of the ZnO/MWCNT membranes to all fish to respond to the fumes of these gases was studied. The highest response was found in the ethanol vapor and at the thickness 71 nm and at the weight ratio 1.624%" for methanol.

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