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RESEARCH ARTICLE

Ethanol sensing properties of spray deposited In: ZnO Thin Films

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ABSTRACT

The influence of dopant precursor (Indium) concentration on Ethanol sensing properties of zinc oxide (ZnO) was studied by fabricating Indium (In) doped ZnO thin films with various In concentration, using spray pyrolysis technique. The effect of In doping (1 at% to 4 at %) on Ethanol sensing properties were studied. The In: ZnO sensors show different responses for different nanostructures. The Ethanol response is higher at an optimum operating temperature of the film and it is lower on either side of operating temperature. The response of 3% In doped ZnO film to Ethanol is considerable than that others.

Keywords: Spray pyrolysis; In-doped ZnO films; Ethanol, response time, recovery time

INTRODUCTION

Since last 70 years zinc oxide (ZnO) has been drawing the attention of researchers worldwide, especially due to its unique properties such as high electrochemical stability, resistivity control, transparency in the visible range with a wide band gap, absence of toxicity, abundance in nature, etc. [1-2]. In the recent past, there has been an increasing degree of awareness on using transition metals as a dopant for ZnO in view of tailoring its electrical, optical and sensing properties [3–5]. Many deposition techniques like molecular beam epitaxy (MBE) [6], RF sputtering [7,8], chemical vapour deposition [9,10], thermal evaporation [11], pulsed laser deposition [12,13], spray pyrolysis [14,15], sol–gel technique [16], etc. were employed for coating ZnO films. Out of these, spray pyrolysis technique has gained a significant degree of interest due to its simplicity, safety and usage of low cost equipments together with less expensive raw materials.

METHODOLOGY

In-ZnO thin films were deposited on the pre-heated glass substrates by simple and cost effective spray pyrolysis technique at 400 ^{0}C, Spray rate 2.5 ml/min, substrate to nozzle distance 30 cm and molar concentration was 0.5 M. The precursor used was Zinc acetate dehydrated ($Zn(C_2H_3O_2)_2.2H_2O$). The Indium chloride was the doping source. The In percentage in the solution was varied from 1 at% to 4 at% in the starting solution. The prepared solution is then sprayed on the heated glass substrates which transforms the solution (mixture) to a stream formed with uniform and fine droplets.

The gas sensor was made by pressing the powder in the form of pellet. The gas sensing characteristics with reference to time at different operating temperatures and concentrations were recorded. The gas response (S) for a given test gas was calculated using following equation.

$$S(\%) = \frac{R_{air} - R_{gas}}{R_{air}} \times 100$$

Where, R_{air} and R_{gas} are the resistance of the sensor in air and in the test gas, respectively.

RESULTS

3.1 Sensing element stabilization

The stabilization of surface resistance of the sensing element under ambient conditions is important to fix R_0 and to calculate the response [17]. Hence, the initial stabilization of was carried out by placing the sample at 250 ^{0}C and found to be stabilized around the resistance of 2.8 × 10^9 Ω shown in Fig.1.

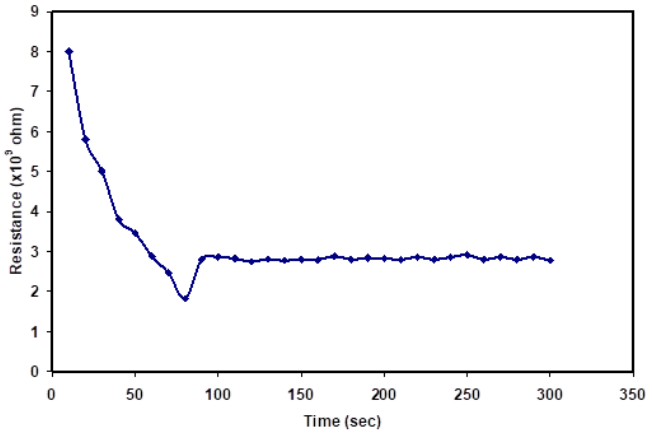

Fig. 1. Stabilization of film resistance (R_0)

3.2 Effect of temperature and Ethanol concentration

Fig. 2 represents the sensing characteristics of the In-doped ZnO films as a function of the operating temperature for 500 ppm concentrations of Ethanol in air. It is observed that In dopant enhances the response of the films to Ethanol. Among all the films, the 3 at% In-doped ZnO film shows the maximum response (~45%) at 300 °C to 500 ppm of Ethanol in air.

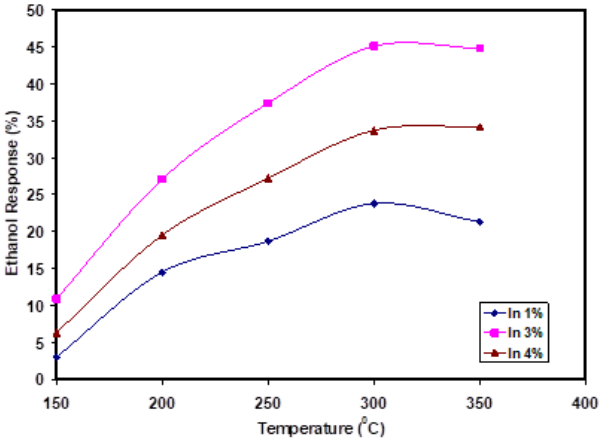

Fig. 2: Ethanol response for different In at% to 500 ppm Ethanol

3.3 Dynamic gas response transients of In: ZnO film to Ethanol

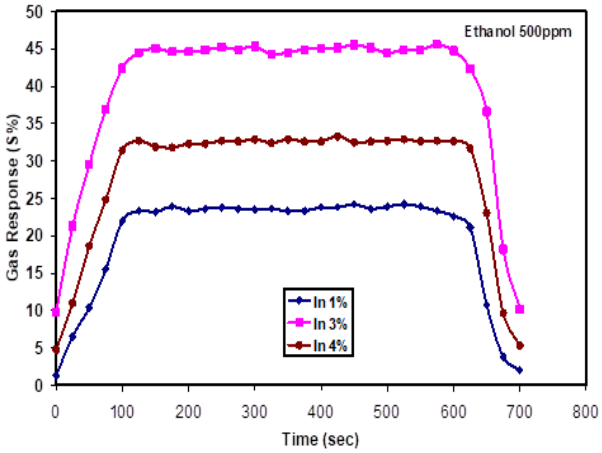

Fig. 3: Dynamic Ethanol transient response of ZnO films

Fig. 3 represents the transient response characteristics of the In doped ZnO films to 500 ppm of Ethanol vapor in air at 300 °C. It is found that in case of the 3 at% In-doped film, the response time to attain the maximum response value 45%.

CONCLUSION

The effect of Indium doping (1 at% to 4 at%) on the Ethanol vapor sensing properties were studied. The sensors response gradually increases up to 300 °C and then starts to saturate. the 3 at% In-doped ZnO film shows the maximum response (~45%) at 300 °C to 500 ppm of Ethanol in air.

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