TEMPERATURE SENSITIVITY OF STANNIC OXIDE AND ZINC OXIDE CO_2 GAS SENSOR

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A B S T R A C T

The sensitivity and stability of the sensor depends on the temperature of the gas sensing element. Most of the metal oxide based gas sensors operate above the room temperature extending up to several hundred degrees centigrade and it is essential to know the precise operating temperatures of these sensing elements. To achieve good sensitivity, one should know and operate these elements accordingly. In present work we prepared a thick film of metal oxides SnO_2 and ZnO by using screen printing technique and analysed by SEM .It was observed that, in a typical case, the sensitivity increases gradually with temperature and becomes less gradual at higher temperature values. From linear dependency, it deviates to a maximum value and beyond this point the sensitivity falls rapidly, such behaviour is being exhibited by almost all the metal oxide-based gas sensor.

Keywords: screen-printing technique; CO_2 gas sensor

1. Introduction:

At present, there is a large interest in implementing sensing devices in order to improve environmental and safety control of gases. The most used gas sensor devices can be divided in three big groups depending on the technology applied in their development: solid state, spectroscopic and optic.While spectroscopic and optic systems are very expensive for domestic use and sometimes difficult to implement in reduced spaces as car engines, the so called solid state sensors present great advantages due to their fast sensing response, simple implementation and low prices [1-5]. These solid state gas sensors are based on the Change of the physical and /or chemical properties of their sensing materials when exposed to different gas atmospheres. Although the number of materials used to implement this kind of devices is huge, this work was centered in studying the semiconductor properties, in those material using SnO_2 and ZnO as sensing materials.

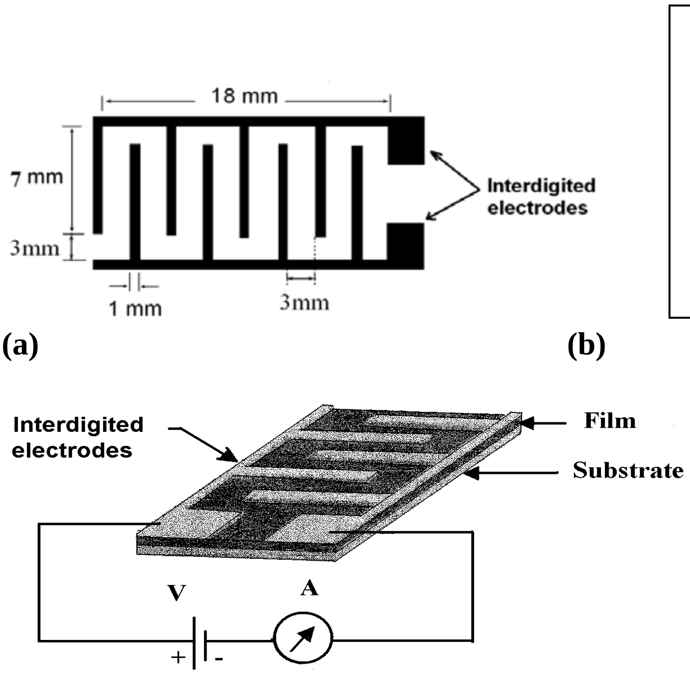
The main purpose of this paper is to study and develop CO_2 gas sensor with new materials for gas sensing elements starting from the knowledge in thick film production using screen-printing technique.

2. Experimental:

2.1 Sensor preparation:

ZnO , SnO_2 and Al_2O_3 powders (AR grade) were calcinated at about 700 °C for 5-6 h and were crushed in mortal pestle to get fine powder of the samples. ZnO ,SnO_2 were characterized by SEM. The ink or paste of the sample was prepared by using screen-printing (thick film technique) technique. The binder for screen-printing was prepared by thoroughly mixing 8 wt% butyl carbitol with 92 wt% ethyl cellulose. On chemically cleaned glass plate, paste of Al_2O_3 was screen printed and it was kept for 24 hr to dry it at room temperature and then heated at 140^0C for 2.5 h to remove the binder. The Al_2O_3 layer provides mechanical support as well as high thermal conductivity. Paste of ZnO and SnO_2 mixed in proper stiochometry was then screen printed on Al_2O_3 layer. Again plate was dried at room temperature for 24 h and binder was removed by heating it at 150^0C for 2.5 h. Finally film is prepared by screen printing, whole plate was dried and again binder was removed as above. Fabrication of multilayer sensor is shown in following fig. (1)

Finally on the top surface of the sensor, interdigited electrodes [6,9] were fabricated using conducting silver paste as shown in the Fig.1 (b)To measure the sensitivity, electrical resistance was measured with the help of voltage drop method, best one.



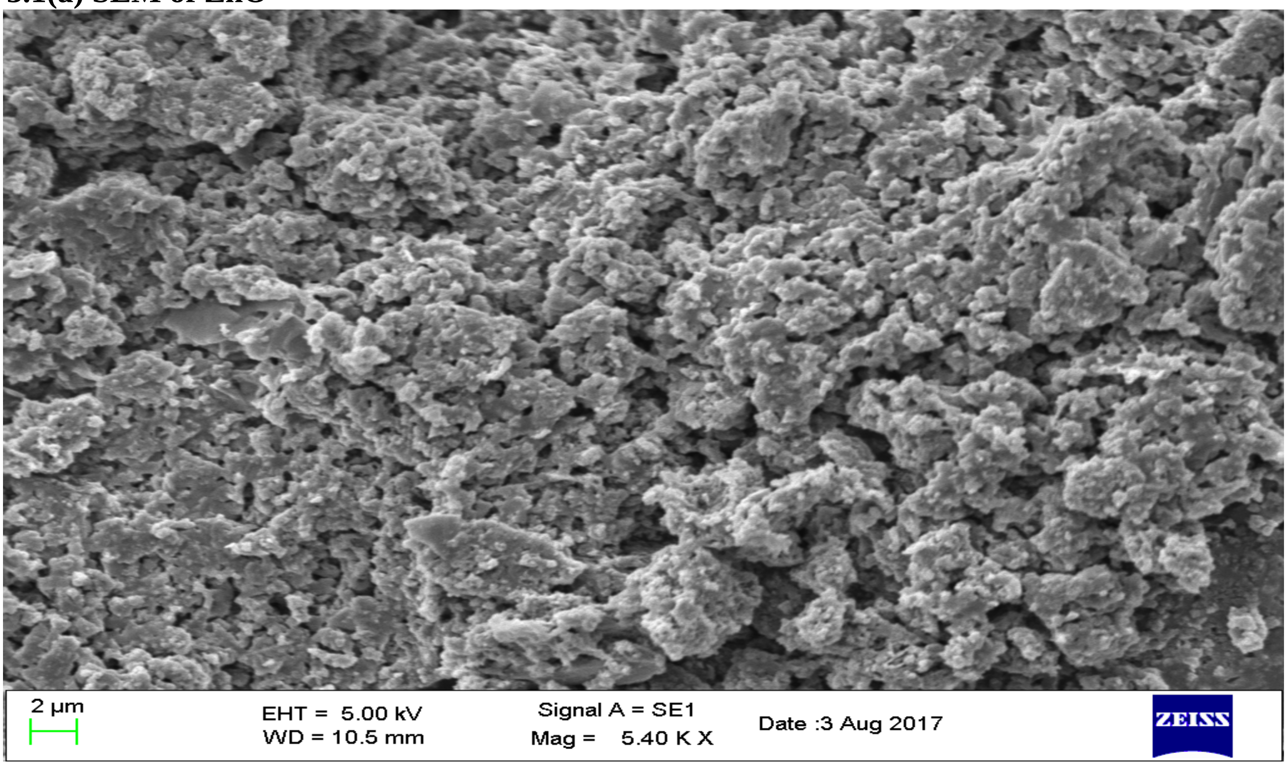
(c)

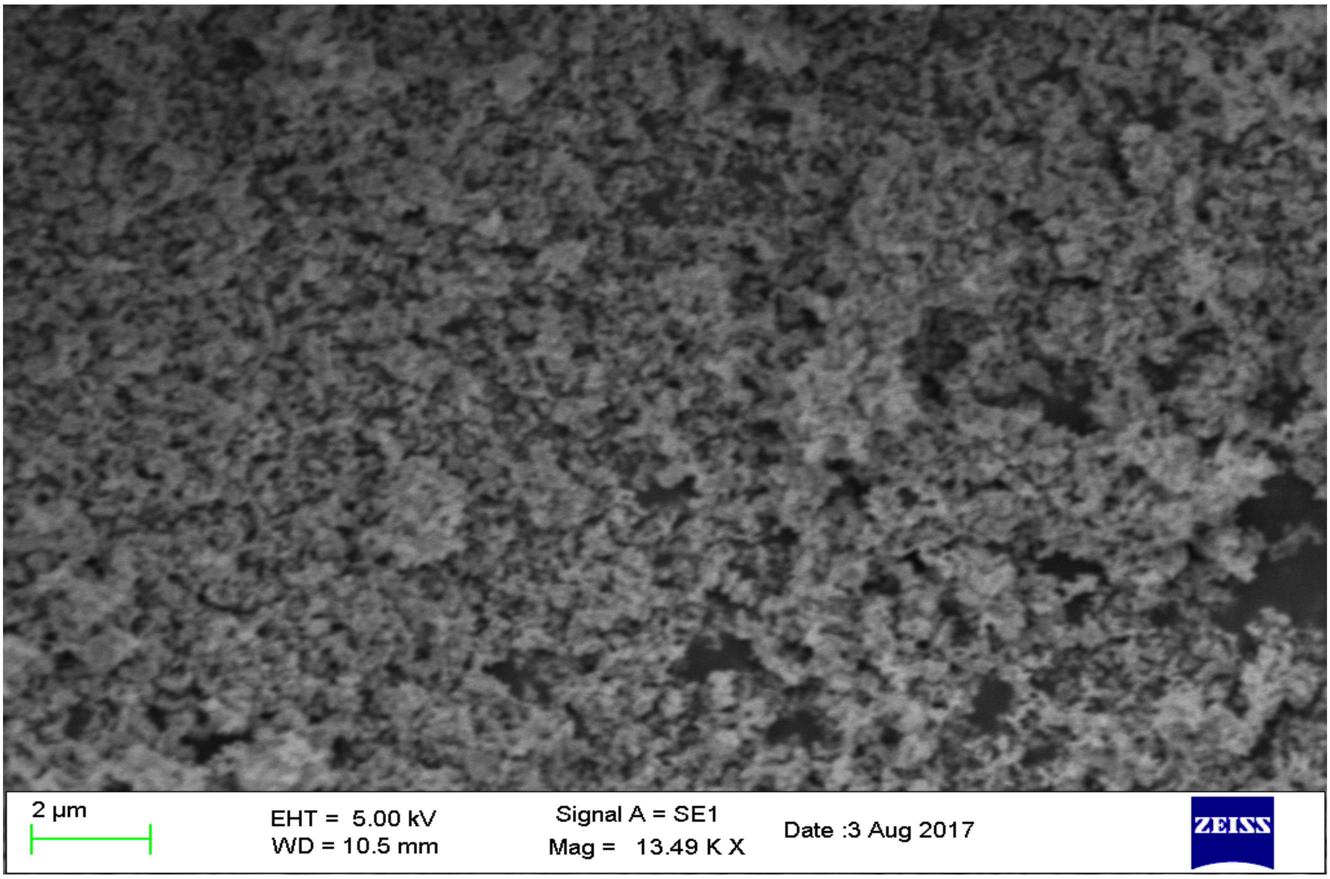
Fig. 1 (a) Fabrication of interdigited Electrodes (b) Actual photograph of interdigited electrodes (c) Circuit of resistance measurement using interdigited electrodes.

3. Results and Discussion:

3.1: SEM

3.1(a) SEM of ZnO





3.1(b) SEM of SnO_2

Above SEM images shows some rods with fine voids over them which helps to enhance gas sensing properties.The surface morphologies of ZnO and SnO_2 materials were studied by SEM and the average diameter and number of pores per inch of ZnO and SnO_2 are as under

Table 3.1 *Average diameter of pore and number of pores per inch of pure samples and their compositions*

Sr. No.	Pure sample and their compositions (mole %)	Average diameter of pore (nm)	Number of pores per inch (in x 2000 magnification)
1.	SnO_2	780	67
2.	ZnO	700	56

From the SEM pictures, it is observed that SnO_2 have maximum pores per inch (calculated for x 2,000 magnification for each composition) than ZnO. Thus SnO_2 have more surface area and exhibit more sensing nature.

3.2: Sensitivity of sensor:

The sensitivity of the sensor is given by equation (2),

$$S = \left(\frac{R_{air} - R_{gas}}{R_{air}} \right) = \left(\frac{\Delta R}{R_{air}} \right) \qquad (2)$$

Where, R_{air} and R_{gas} are the resistances of sensors in air and gas respectively. Maximum sensitivity was recorded for multilayer sensor at 70 ppm concentration of CO_2

Sample Codes:

Sr. No.	**Pure**	**Codes**
1	SnO_2	P1
2	ZnO	P2

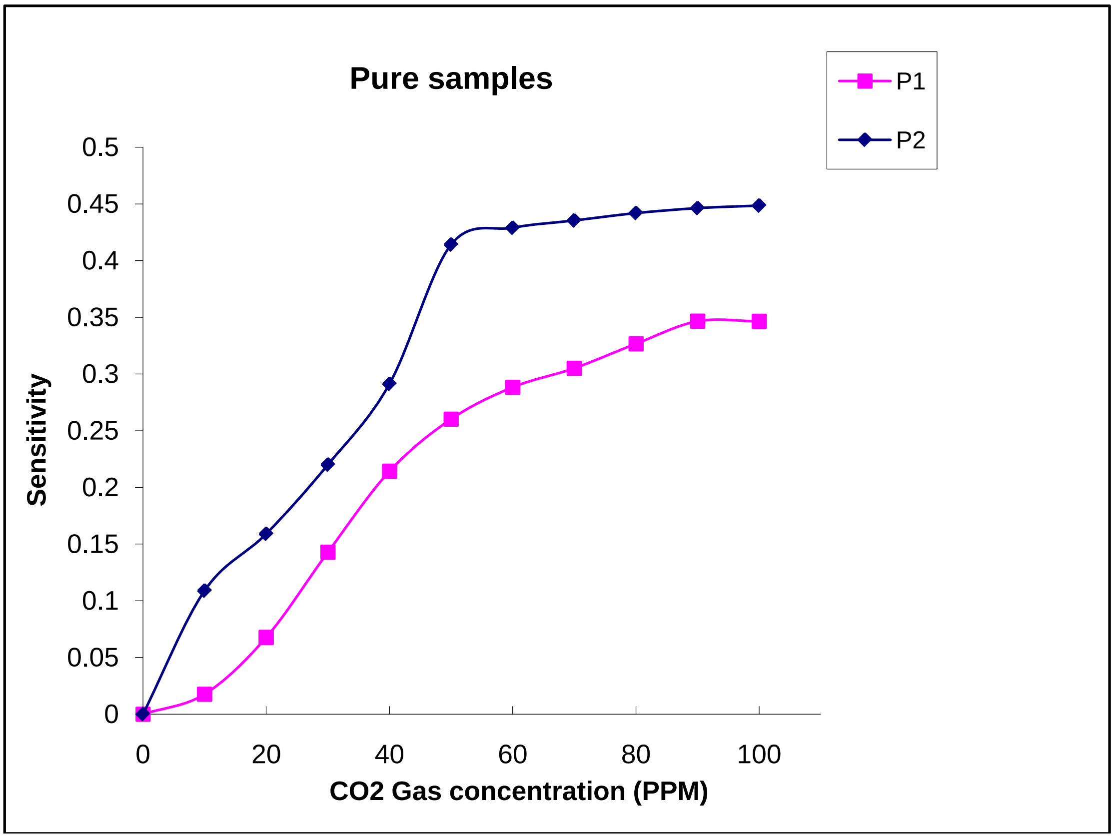
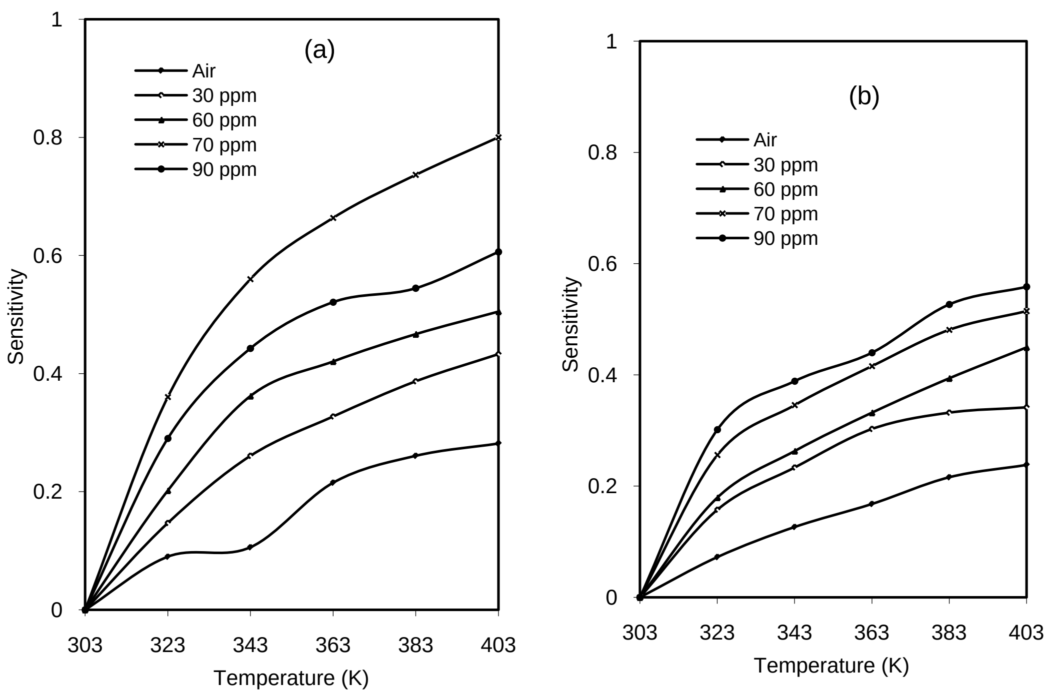


Fig.(2) Variation of sensitivity with of CO_2 gas concentration for SnO_2 and ZnO_2



Fig(3) (a) Variation of Sensitivity with temperature for SnO_2 (b) Variation of Sensitivity with temperature for ZnO.

It was observed that, in a typical case,the sensitivity increases gradually with temperature and becomes less gradual at higher temperature values. From linear dependency, it deviates to a maximum value and beyond this point the sensitivity falls rapidly, such behavior is being exhibited by almost all the metal oxide-based gas sensor

3.5 Stability of sensor:

Rate of change of resistance of the sensor with respect to time defines the stability of the sensor. A sensor should be more stable for its better response. It is observed that resistance of SnO_2 sensor does not change drastically as that in case of ZnO samples.

4. Conclusions:

From SEM characterization it is concluded that the crystallite size of SnO_2 is smaller,more porus and hence has greater surface area and therefore shows greater response to CO_2 gas. Screen printing technique is the easiest for the preparation of sensor. SnO_2 sensor shows good stability than ZnO samples and dynamic response of SnO_2 is also fast. In present work we prepared a thick film of metal oxides SnO2 and ZnO by using screen printing technique and analysed by SEM .

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