Tin Oxide (SnO_2) Doped with Polypyrrole (PPy) Screen-printed Multilayer CO_2 Gas Sensor[1]

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ABSTRACT

The multilayer thick films series of sensors (SnO_2-PPy) tested for CO_2 gas sensing application in the concentration range from 200 ppm to 2000 ppm, sensitivity increases is very small upto 1200ppm but beyond 1400 ppm of CO_2 gas concentration, sensitivity becomes maximum. With further increase in CO_2 gas concentration, sensitivity decreases. Static responses of the series of (SnO_2:PPy) system also studied at 1000, 1200 and 1400 ppm of CO_2 gas concentration. sensor shows less response time and less recovery time, F5 sensor is faster in operation that other prepared sensors. F5 sensor (92SnO_2:8 PPy) offers high sensitivity, rapid response and recovery to CO_2 gas.

Keywords: *SnO_2-PPy; multilayer thick films; CO_2 Gas Sensors*

INTRODUCTION

Gas sensors consisting of metal oxides like SnO_2 , TiO_2, ZnO and others employ a variation of electrical conductance by ambient gases such as ethanol, carbon monoxide, methane, hydrogen sulfide, nitrogen oxide, and oxygen [1]. The effects of additive of various metals and metal oxides on SnO_2 , TiO_2, ZnO and others sensors are examined by Yamazoe *et al.* [2]. They found that gas sensitivity usually goes through a maximum with increasing nature. The effects of additives can be appropriately compared in terms of the temperature at the maximum of gas sensitivity. A new type of CO_2 gas sensor was developed by Masayuki *et al.* [3] using porous hydroxyapalite ceramics, both DC and AC conductivities measurement were earned out in various atmospheres including air, CO_2 and air containing different amount of CO_2. Thick films of SnO_2, ZnO, TiO_2 were prepared by screen printing technique and studied by Mude *et al.* [4] result the semiconducting metal oxide gas sensor extensively used in the gas sensing. The chemical used for the designing of gas sensor was first calcinated at 650°C for 6 hrs. Thick films of SnO_2, ZnO, TiO_2 were prepared using screen printing technique with Al_2O_3 as substrate on glass plate. Sensitivity was found to be more for SnO_2 than other metal oxides. It was observed that stability is found better in SnO_2 as compare with other metal oxides, sensitivity is also more as compare to other metal oxides. This paper focused on CO_2 gas sensing application of (SnO_2-ppy) multilayer thick films system with Al_2O_3 as base material.

EXPERIMENTAL

The methods of synthesis of nano-particles can be broadly classified in the three categories namely, liquid phase synthesis, gas-phase synthesis and vapour-phase synthesis . In the present work, we have used sol-gel method for the synthesis of pristine nano-particles of SnO_2, Al_2O_3 and PPy [5].

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Preparation of Samples of Series : SnO_2: PPy/Al_2O_3/GP

The obtained product of fine nanopowder of SnO_2 and PPy are used for fabrication of thick films sensors by using screen-printing technique. For this, the SnO_2 powder was mixed thoroughly with different X mole% of PPy (X = 2, 4, 6, 8,10) along with Al_2O_3 base on glass plate (GP) substrate the aid of acetone by using the mortar and pestle. The sample codes, mole% of powder, and thickness are listed in the Table 1**.** The mixed powder of SnO_2:PPy system was further calcinated at temperature 800°C for 5hrs. in the auto controlled muffle furnace (Gayatri Scientific, Mumbai, India.) After, the calcinations again uniformly mixed the powder using the grinder

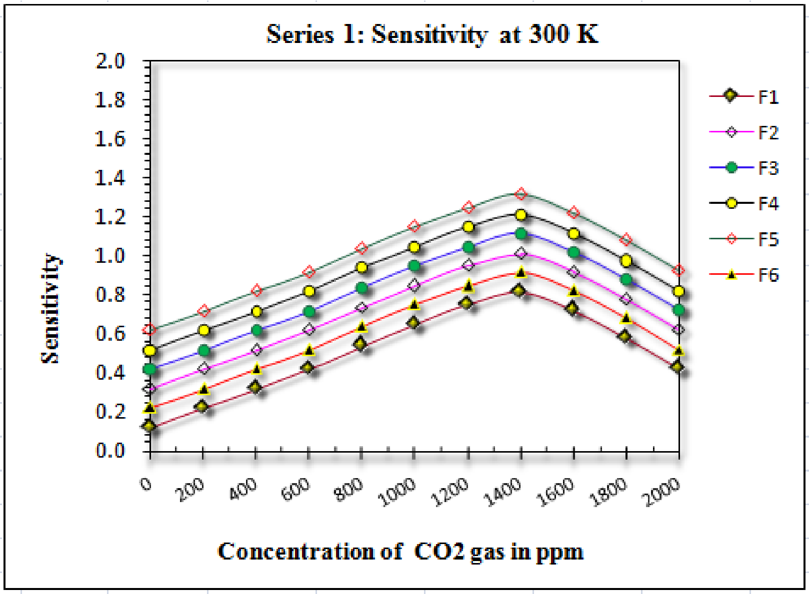
Table 1 Length, Width and Thickness of Multi-layers in SnO_2: PPy/Al_2O_3/GP gas sensor

Sample Code	Doping mole % Layers: Upper/ /Al_2O_3/ Glass plate (GP)	Upper layer length (cm)	Upper layer width (cm)	Thickness (x 10-4 cm)		
				Upper Layer (1)	Al_2O_3 Layer (2)	Total (1+2)
F1	SnO_2/Al_2O_3/GP	3	1.5	5.1	26.4	31.5
F2	98 SnO_2:2 PPy/ Al_2O_3/GP	3	1.5	3.1	34.2	37.3
F3	96 SnO_2:4 PPy/ Al_2O_3/GP	3	1.5	2.8	35.1	37.9
F4	94 SnO_2:6 PPy/ Al_2O_3/GP	3	1.5	3.4	32.6	36.0
F5	92 SnO_2:8 PPy/ Al_2O_3/GP	3	1.5	3.0	35.5	38.5
F6	90 SnO_2:10 PPy/ Al_2O_3/GP	3	1.5	3.6	32.3	35.9
F7	PPy/ Al2O3/GP	3	1.5	1.9	48.4	50.3

RESULTS AND DISCUSSION

CO_2 Gas Sensing Properties at room temperature (300 K) & at (330 K)

The variations of sensitivities and sensors with concentration of CO_2 gas at 300K and 330K temperature are shown below;



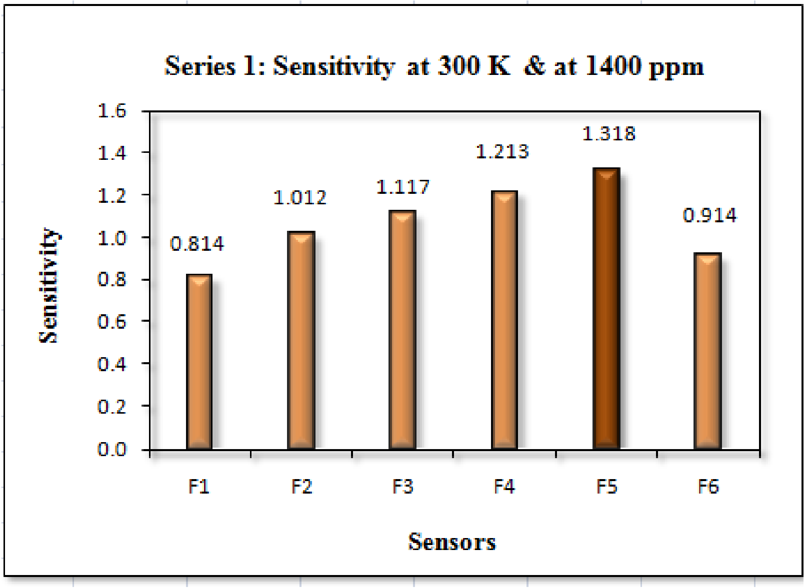
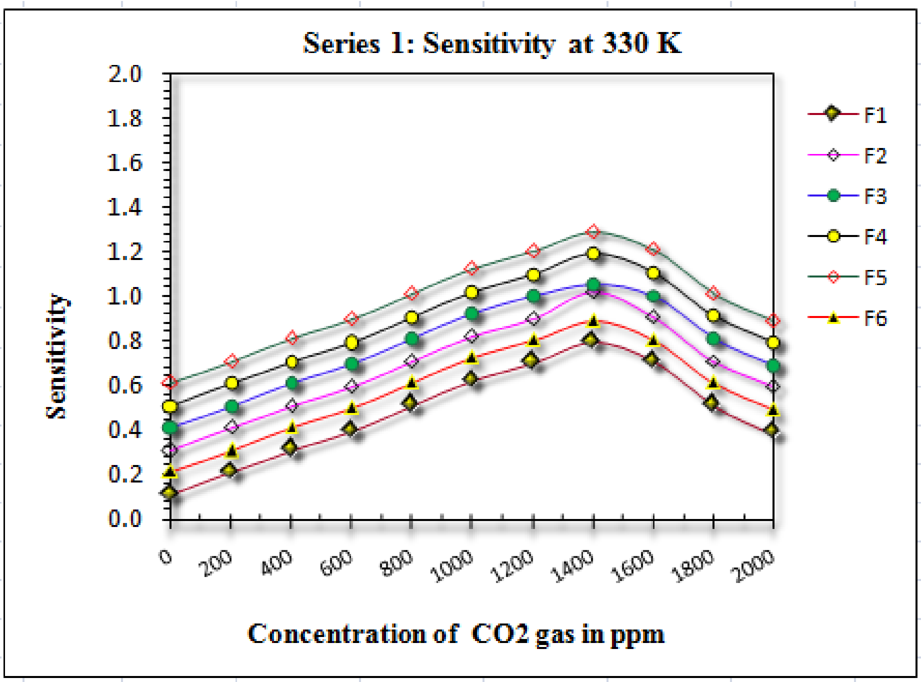


Fig. 1: variations of sensitivity with CO_2 gas concentration at 300 K



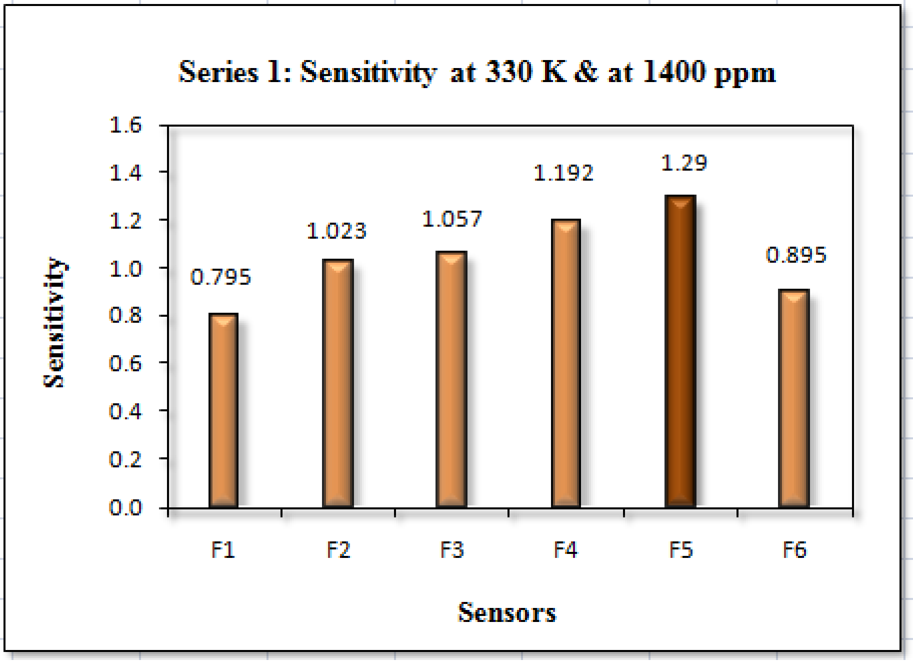


Fig. 2: variations of sensitivity with CO_2 gas concentration at 330 K

From Fig. 1 and 2 for the CO_2 gas detection and sensing at room temperature (300 K) and at temperature 330 K respectively, exhibited that,

As CO_2 gas concentration increases up-to 1200 ppm, sensitivity increases by small amount. At about 1400 ppm of CO_2 gas concentration, sensitivity becomes maximum. With further increase in CO_2 gas concentration, sensitivity decreases. From Fig. 2 (Bar Graph), sensitivity was found to be 1.318 (maximum) for F5 sensor, amongst the prepared all sensors. From figures, it is manifested that, as temperature increases, sensitivity decreases because size of porosity increases and therefore number of pores in given area decreases. This means that the prepared sensors work better at room temperature (300 K). In brief, among the prepared sensors, F5 sensor showed optimum sensitivity at 1400 ppm of CO_2 gas concentration [6,7].

Static Responses of sensors

Static responses of the series of (SnO_2:PPy) system , was studied at 1000, 1200 and 1400 ppm of CO_2 gas concentration [8-10]. The variation in sensitivity was plotted as a function of time in second. From the variations, response and recovery times were calculated and listed in the following tables, separately for each series. Static response of this series at 1000, 1200 and 1400 ppm of CO_2 gas concentration is shown Fig. 3.

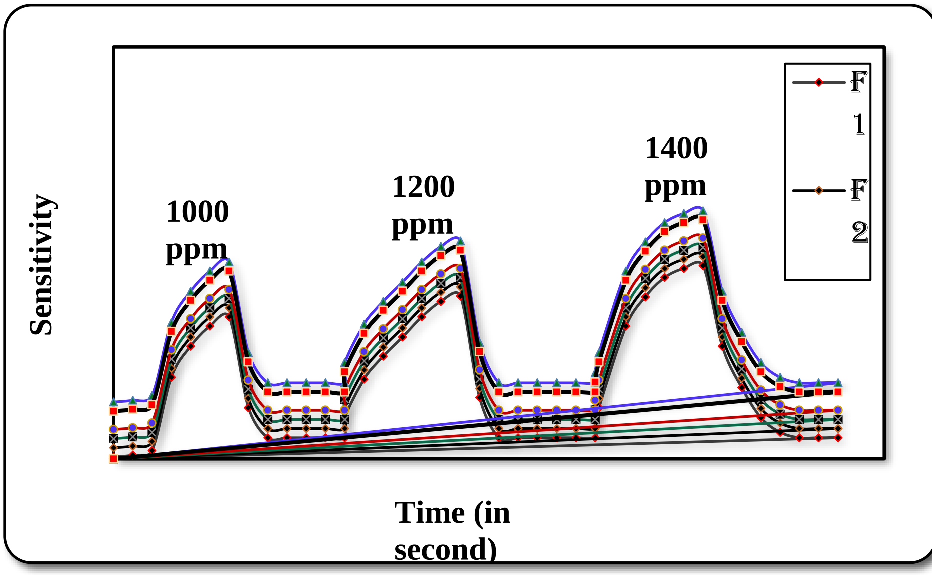


Fig. 3.: Static response (response and recovery times) of series of (SnO_2:PPy) system

Table 2. Response and Recovery times of series of (SnO_2:PPy) system

Sr. No.	Sample Compositions	Sensor	Response time (s) for 1400 ppm	Recovery time (s) for 1400 ppm
1	$100SnO_2$:0 PPy/Al_2O_3/GP	F1	118	152
2	$98SnO_2$:2 PPy/ Al_2O_3/GP	F2	103	149
3	$96SnO_2$:4 PPy/ Al_2O_3/GP	F3	97	143
4	$94SnO_2$:6 PPy/ Al_2O_3/GP	F4	91	139
5	$92SnO_2$:8 PPy/ Al_2O_3/GP	F5	81	129
6	$90SnO_2$:10 PPy/ Al_2O_3/GP	F6	89	134

From table 2, it is clear that, F5 sensor shows less response time (81 s) and less recovery time (129 s), i.e. F5 sensor is faster in operation that other prepared sensors from series (SnO_2:PPy) .

CONCLUSIONS

F5 sensor shows less response time and less recovery time, therefore F5 sensor is faster in operation that other prepared sensors from series (SnO_2:PPy). The sample F5 sensor ($92SnO_2$:8 PPy/ Al_2O_3/GP) offers high sensitivity, rapid response and recovery to CO_2 gas.

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