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Polymer embedded Zirconium oxide for LPG Gas Sensing Applications

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ABSTRACT
In this paper, we demonstrate a novel and direct synthesis of polymer embedded Zirconium oxide at very low temperature of ~100^oC for gas sensing application. The formation of thin film of polymer embed ZrO_2 were obtained byspray pyrolysis technique.The gas sensing properties were studied of all the samples for 1000 ppm LPG concentration by measuring the change in resistance with various operating temperature. A very high value of sensitivity (SF= 120) is obtained for 1weight percentage (wt %) samples at an optimum operating temperature of 45^oC and 5wt% samples (SF= 100) at 35^oC. However, for other additive concentration it is found to be less. The gas sensing characteristics of these films are strongly influenced by concentration level of the additive. Thus correlating the additive and electrical properties can lead to an enhancement of the material potential for gas sensing application.

KEYWORDS: *ZrO_2, LPG gas sensor.*

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I. INTRODUCTION:

Now days, there has been increasing of ecological perception, fitness, and safety involving greenhouse gasses, inflammable and poisonous gases etc. As a result, there is a emergent requirement of reliable and contemptible gas sensor. Polymer embedded Metal oxide semiconductor is the most widely used to detect oxidizing gases and prevent it from wetness atmosphere. Moreover, it is well new way to improve Metal Oxide semiconductor sensor by modifying the surface morphology with the help of polymer embedded technique.

In the present study, we are describing the synthesis of Polymer embedded Metal oxide film using the spray technique with a organic structure-directing agent in synthesis process. The samples obtain from polymer embedded metal oxide films were heated at particular temperatures. Finally, the samples after heat treatment were characterized as a gas sensor-using surface measurement system. The film sensor consisted of electrode pads. The sensor performance is investigated on gas flow at varioustemperatures.

II. EXPERIMENTATION:

Standard commercially available Zirconium oxychloride (99.8 % pure, SISCO RESARCH PVT LTD) and pureDiethyleneGlycol (S.D. Fine chime Ltd) were used to prepare thin films. Thin films of Zr/ZrO_2were prepared embedded in Di ethylene Glycol. To prepare films,initially, 1 molar solution of Diethylene Glycol and Zirconia Oxichloride, respectively,were prepared. Five different solutions were preparedby taking the concentrations of above prepared solutions as 1:99, 2:98,3:97,4:96, and 5:95. Thin film of each of concentration was prepared by spray pyrolysis method, glass slides used as substrate.

Sensing properties were studied for all the samples for LPG by recording the change in the voltageacross the sample by half bridge method. Since the resistance of sample was very high, the voltage drop acrossit was very large. Values of resistances of the sample at different temperatures were calculated,when exposed to ambient air (R_a) and LPG (R_g), respectively.The sensitivity was calculated by (R_g/R_a)*100.

III. RESULTS AND DISCUSSION

As already reported before, the gas sensitivity wasalmost linear to the concentration of LPGat 1000 ppm form RT to100°C for the ZrO_2based device.. The gas sensitivity is defined here as thedifference between the resistance (|Z|air) in the base airand the resistance (|Z|gas) in thesample gas.

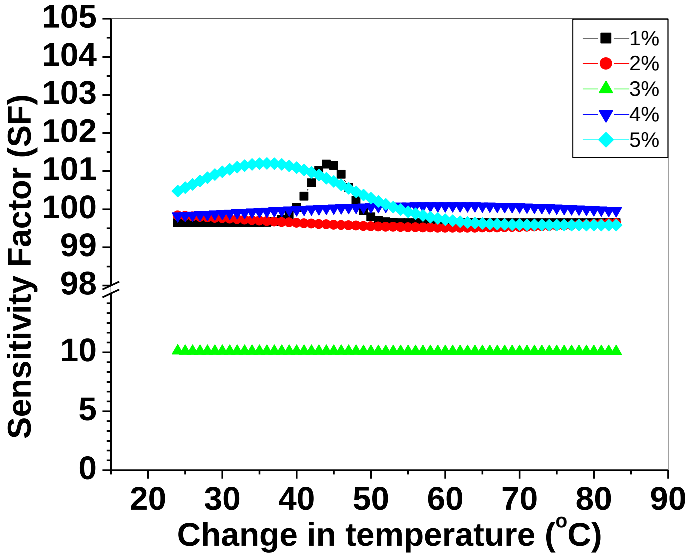

Fig 1. Variation of Sensitivity with change in operating temperature for different 1, 2, 3, 4, 5 wt% modified samples (1000 ppm LPG)

From fig. 1.As for a hydrocarbon sensor, it was found to give good selectivity to LPG for 1wt % samples (SF=110) at an optimum operating temperature of 45^{o}C, However, it has shown sensitivity to 5wt% (SF=105) at 35^{o}C even at low temperature, but the temperature window for 1wt% samples is less as compared 5wt% sample. All the other weight percentage i.e. The response and recovery responses were rather quick. Further investigation on this LPG sensor is now in progress.It seems that both adsorption and combustion of the reducinggases occur on the surface of the sensors. The depletionof the lattice oxygen might be responsible for the sensitivityof the sensor to the gases. The ZrO_2 is a lower temperaturesemiconductor than other oxide and exchanges lattice oxygen withsurface and gas-phase oxygen more easily.We speculate thatat 35◦C, the LPG can extract more oxygen from the latticeof the sensor, while for the ZrO_2 sensor the lattice oxygenis more easily replaced from the gas. As the temperature isincreased, the ZrO_2 also can exchange lattice oxygen withsurface and the gas. The dramatic effect of Zirconium on LPG selectivityneeds further investigation.

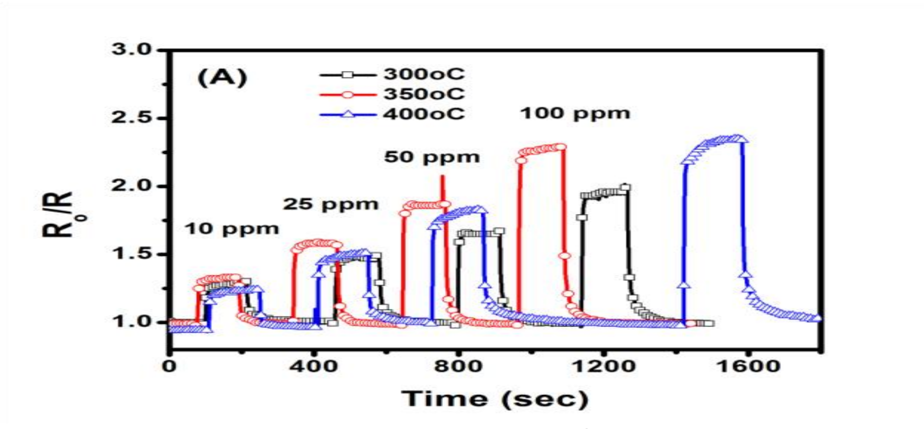

Fig 2: LPG sensing properties of the ZrO2

The LPG sensing properties of synthesized nanosensors are shown in Fig.2. The nanosensorexhibites a similar trend of response to that with CO gas, where the sensor resistance decreased rapidly upon exposure to LPG gas. The nanosensor could detect LPG gas at a very low concentration of ppm level, which is much lower than the “lower explosive limit (~4%)”, suggesting a possibility of using for practical application in monitoring of LPG leak in air. The sensor response of the porous ZrO_2 thin film was higher than that of the condensed once, whereas the sensitivity to 500 ppm LPG concentration measured at 300 ^{o}C was about 27 and 4.5 for the porous and condensed nanosensors, respectively. The higher sensitivity of the porous ZrO_2nanosensor was possibly due to the porous structure of ZrO_2thin filmwhich provided larger sensing sites for gas adsorption and resulted in higher sensitivity.

IV. CONCLUSIONS

The polymer embedded ZrO_2-based materials used in gas sensors have received great attention. The high and selective absorption properties of polymer embedded ZrO_2 towards a specific gas greatly enhance the sensing selectivity for the gas. The compound or cluster sensing towards a gas assembled into the cages or channels of polymer embedded ZrO_2 results in its high stability, and maximally elevate the sensing property of the materials. The application of composite materials partially composed of a polymer, opens novel ways for choosing gas sensor materials as well. However, much more works remains to be done. Overall, we foresee that polymer embedded polymer embedded ZrO_2 will become widely available materials for gas sensing in the next few years.

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