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Gas Sensing Properties of Zn-Doped TIN Oxide Nanoparticles with Methanol

KEYWORDS: Aliovalent; Light-Emitting Diodes (LEDs); Preadsorbed; Diffractometer etc.

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ABSTRACT *Tin oxide, an n-type wide direct band gap semiconductor is promisingly used material for detection of wide variety of gases such as LPG, NO_2, CO, H_2S and volatile organic compound (VOC'S) and many different applications such as high-performance capacitive behaviour, transparent conducting electrodes, transistors, light-emitting diodes (LEDs) and solar cells. The electrical conductivity of the SnO_2 nanoparticles are dependent on the density of preadsorbed oxygen ions on its surface. The detection mechanism of gas is based on the reversible change of conductivity of the surface of metal oxide semiconductors particles/grains induced by gas-solid interaction. Several strategies have been adopted to enhance the performance of SnO_2 gas sensors; including doping with aliovalent ions (e.g. Cu, Zn, In), catalytically active additives.*

INTRODUCTION:
Methanol is highly toxic, harmful and often fatal to human beings, therefore there is the need of development of a highly reliable and selective alcohol sensor with cost effective. So the study of Methanol sensing response of Zn-doped nanoparticles has been reported in this article. Out study shows that the Zn-doped nanoparticles exhibit a high sensitivity and short response/recovery time at very low temperature range 150 and 250 [1].

STRUCTURAL ANALYSIS:
The Structural analysis of the Zn-doped nanoparticles were carried out by using X-ray diffractometer with high-intensity Cu radiation (λ=1.5418) a X-ray source at 40 kV and 30mA in the scanning angle from 20° to 65°. Figure 1 shows XRD pattern of as synthesized Zn-doped nanoparticles [2]. The crystallite size is found to be 15, 13 nm for 1 at.% Zn and 3at.% Zn-doped nanoparticles respectively.

Figure 2(a-b) represents the methanol sensing characteristics of 1at.% and 3 at.% Zn-doped nanoparticles as a function of operating temperature in the range 150-250. The Zn-doped (1 at.% Zn, 3 at.%) nanoparticles show n-type semiconducting behaviour. The electrical resistance decreases under exposure to methanol acting as a reducing gas and increases under recovering in air. The 3 at.% Zn-dopednanoparticles show maximum response (~83%) at 250 to 50 ppm methanol is air. This attributed to the combined effect of smaller crystallite size and very low lattice strain [3]. Smaller crystallite size means larger surface to volume ratio resulting greater oxygen absorption on the surface of the leads higher response and low lattice strain corresponds to minimum scattering of electrons by defect levels which is another reason for increasing response. At low operating temperature below 200 the response is restricted by the speed of chemical reaction that means the electron do not have enough thermal energy to cross the potential barrier to go to the conduction band. In all the cases the response is found to be high at higher temperature 250 because of sufficient availability of oxygen species to react with test gas.

Methanol gas sensing mechanism is based on chemisorptions process. Generally, when metal oxide semiconductor gas sensor is heated in air, atmospheric oxygen species may be adsorbed on the surface of sensor, and then ionized in the form of by capturing free electrons from the conduction band of[4]. When the sample is exposed to a test gas of methanol vapour at an operating temperature, methanol would react with and releasing electrons. Here, methanol is oxidized to formaldehyde and subsequently formic acid, and literates electrons into the conduction band, thereby decreasing the resistance of the surface of upon exposure to methanol vapour in air.

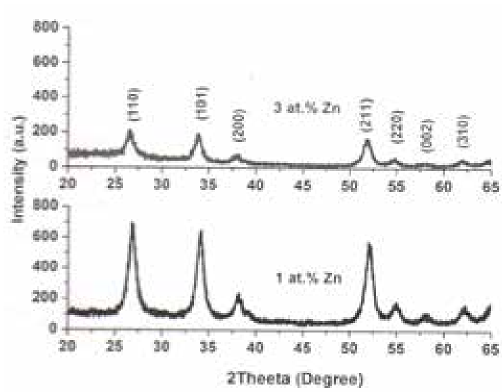

FIGURE 1: XRD pattern of Zn-doped nanoparticles (1%, 3%)

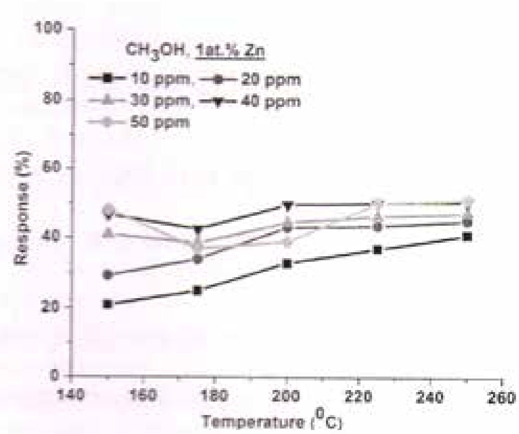

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FIGURE 2 (a)

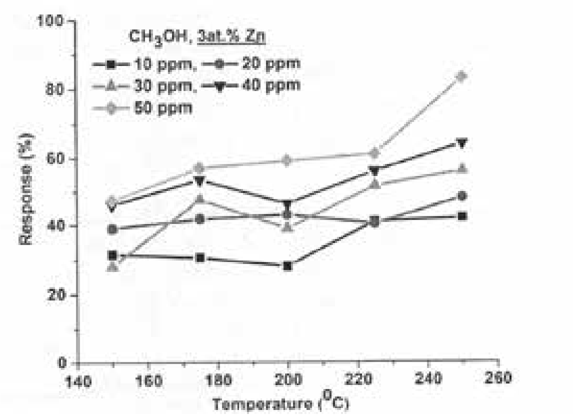

FIGURE 2(a-b): Methanol sensing characteristics of Zn-doped nanoparticles (1%, 3%) and temperature range 150-250.

CONCLUSIONS:

The Zn-doped nanoparticles have been synthesized by chemical coprecipitation method. The XRD pattern reveals that as synthesized material has tetragonal rutile structure. The crystallite size of the (for 1at.% and 3 at.%) Zn-doped nanoparticles is estimated 15 and 13 nm respectively. The methanol sensing properties of Zn-doped nanoparticles for various concentrations (10, 50ppm), it is concluded that for a concentration of 50 ppm, the 3 at.% Zn-doped sample shows the maximum response (~83%) to methanol at an operating temperature of 250. In all temperature and concentrations, the response/ recovery found to be fast and robust user friendly and also cost effective.

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