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Study of H_2S Gas Sensing Properties of Zinc Oxide Nanorods

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ABSTRACT *Zinc Oxide nanorods have been synthesized and studied as the sensing element for the detection of H_2S. For gas sensors, nanostructures have advantages of improved gas-sensing characteristics. In this paper, ZnO nanostructures have been prepared by hydrothermal methods. Oxide semiconductors sense gases by their interaction with adsorbed oxygen on the surface. Adsorbed oxygen traps electrons from bulk of semiconductor and interaction with various reducing (H_2S, NH_3, H_2 etc.) and oxidizing gases (NO,O_3) results in change in concentration of trapping centers. The results show that nanorods of pure and anneal ZnO are highly sensitive for Maximum operating temperature (~330 ^{0}) detection of H_2S. These ZnO nanostrcutres were characterized by SEM and Photoluminescence (PL). ZnO nanostructure synthesized by this method can be used as a promising material for semiconductor gas sensor to detect poisonous gas like H_2S at room temperature with high sensitivity and selectivity.*

INTRODUCTION:

Normally, most of the nanostructures gas sensors operate on the basis of a change in electrical properties of the active element, which adsorbs on the surface of the sensor. A gas sensor has two main parts; a gas sensing element and a transducer [1]. When a gas molecule is adsorbed on the surface of gas sensing element, it produces a response, which is translated into measurable signal by a transducer. The change in the signal can be measured by signal processor. ZnO is an important n-type semiconductor with a wide band gap energy and a large band gap at room temperature. It is an important functional oxide, exhibiting near ultraviolet emission and transparent conductivity. Secondly, because of its noncentral symmetry, ZnO is piezoelectric, which is a key property in building electromechanical couples sensors and transducers. ZnO is one of the most promising materials for gas sensor application [2]. An n-type semiconductor can be obtained either through an excess of metal (for example, ZnO) or a deficit of non metal (for example,). n-type behaviour of oxides can be caused by non-metal deficit. This can be visualized as the discharge and subsequent evaporation of an oxygen ion. The electrons enter the conduction band and a vacancy is created on the anion lattice [3].

NANOSTRUCTURE GROWTH AND CHARACTERIZATION:

A solution is prepared by using NaOH solution in methanol that as added slowly by drop wise to a solution of zinc acetate dehydrate (0.01 M) in methanol at 70℃ under constant stirring for two hours. Nanoparticle seed layer from this solution were formed by spin coating on Si wafers. The uniformly coated silicon wafer with zinc acetate seeds layers used for hydrothermal growth carried out by suspending the wafer with zinc acetate seeds layers used for hydrothermal growth carried out by suspending the wafer upside-down in an open crystallizing dish filled with an aqueous solution of zinc nitrate hydrate (0.02M) and methylamine or diethylenenetriamine (0.02 M) at 100℃ for 8, 16 and 24 hours. The wafer was then removed from solution, rinsed with de-ionized water, and dried [4]. This low temperature method produces high-quality nanorod/nanowire arrays on substrates figure(a). A scanning electron microscope (SEM) was used to examine the morphology of the as grown nanorods/nanowires array across the entire wafer, nanowire crystallinity and growth direction were analyzed by X-ray diffraction.

RESULT AND DISCUSSION:

Optical Properties:

Photoluminescence (PL) is the spontaneous emission of light from a material under optical excitation. The excitation energy and intensity can be chosen to probe different excitation types and also different parts of the sample.

The PL can be collected and analyzed to provide information about the photo excited states. The PL spectrum reveals transition energies and the PL intensity gives a measure of the relative rates of radiative and non-radiative recombination. Variation of the PL intensity upon change of external parameters, e.g., temperature, excitation energy, power of excitation, can be used to further characterize electronic states and bands.

Fig. (b) shows the PL spectra of ZnO NR which exhibit two characterstics peak at 378 nm and 55o nm respectively. The peak at 378 nm is a characteristic near band edge (NBE) emission (band gap = 3.2 eV) of ZnO. The other peak at 550 nm has been mainly assigned to the defects in ZnO and mostly referred to as green emission. Presence of oxygen and Zn defects like interstitial and vacancies are mainly attributed for this peak. As shown in fig. (b), the nanorods exhibit a near band edge emission and green emission peaks. The high intensity of NBE peak for NR implies a high crystal quality for this structure.

H_2S SENSING PROPERTIES:

As grown and annealed nanoparticles (spin coated on Si wafer), nanorods and nanowires were investigated for possible gas sensing application. The sensor films were analyzed for their response towards toxic gases namely. The sensor response defined as

$$S = \frac{(R_g - R_a) \times 100}{R_g}$$

Where resistances in air and gas respectively.

ZnO NR exhibited n-type response upon exposure to different gases. Accordingly figure (c) shows the effect of different concentration on both fresh and annealed ZnO NR

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towards. In these sensors the resistance was found to decrease on exposure to and increased on exposure to. This result is as expected for an n-type semiconductor, on interaction with reducing () and oxidizing gases, respectively. Interestingly, for both the cases the operating temperature for maximum sensitivity is towards 10ppm of in comparison of that of 5 ppm (figure c).

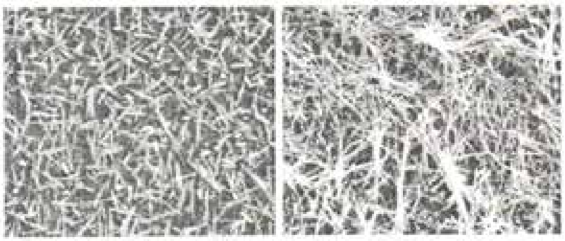

Fig. (a) SEM images of ZnO nanorods growth using ZnO nanoparticles seed layer by hydrothermal growth

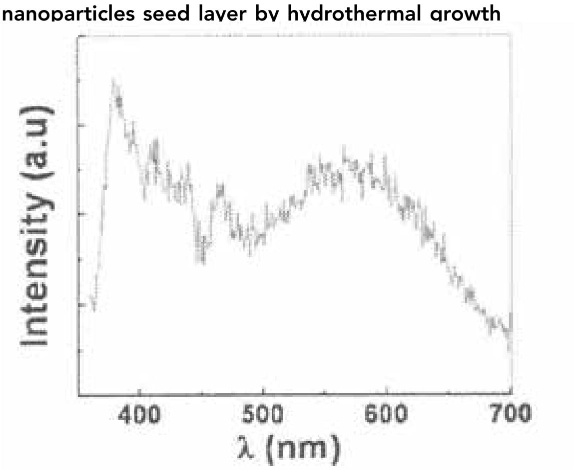

Fig. (b) PL spectra of ZnO NR

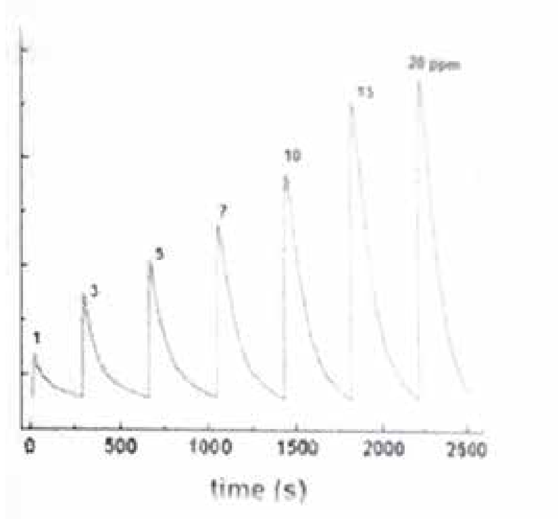

Fig. (c) ZnO NR Histogram for many gases and Sensor response towards increasing conc. Of

CONCLUSION

Above results shows that nanorods of pure and anneal ZnO are highly sensitive for maximum operating temperature (~330℃) detection of gas.

REFERENCE 1. X. Deng, F. Wang and Z. Chen, "A Novel Electrochemical Sensor Based on Nano-Structured Film Electrode for Monitoring Nitric Oxide in Living Tissues," Talanta, Vol. 82, No. 4, 2010, pp. | 2. H. Xu, X. Liu, D. Cui, M. Li and M. Jiang, "A Novel Method for Improving the Performance of ZnO Gas Sensors," Sensors and Actuators B: Chemical, Vol. 114, No. 1, 2006, pp. 301-307. | 3. Z. Jing and J. Zhan, "Fabrication and Gas-Sensing Properties of Porous ZnO Nanoplates," Journal of Advanced Materials, Vol. 20, 2008, pp. 4547-4551. | 4. P. Feng, Q. Wan and T. H. Wang, "Contact-Controlled Sensing Properties of Flowerlike ZnO Nanostructures," Applied Physics Letters, Vol. 87, No. 21, 2007 |