UGC Minor Research Project

Development and Implementation of Nanocrystalline Metal Oxide Gas Sensor Array Network for Pollution Monitoring

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Principal Investigator

Dr. G. S. Shahane
Department of Electronics
DBF Dayanand College of Arts and Science,
Solapur, MS, India

Exhaustive Summery

As global warming is burning issue of the twenty first century, due to usage of petroleum based vehicles, air conditioners and refrigerators air pollutants are increased, which causes the human health problems and unbalanced environmental conditions. An electronic sensor system is highly desirable to provide continuous monitoring of the chemical composition of gas emitted from combustion systems, in order to minimize air pollutions, and maintain the concentrations of dangerous gaseous species within the limits stipulated by regulations. These demands require the detection with high sensitivity, selectivity and reliability towards the very low concentrations of air pollutant such as CO_2, CO, CH_4, Cl, NO_x and also other toxic gases. Semiconductor metal oxide (SMO) gas sensors are considered as one of the basic technologies for identification and measuring the concentrations of gas in combustion atmosphere. These devices offer a wide variety of advantages such as low cost, short response and recovery time, easy manufacturing and small size. Considerable research into new sensors and detectors, including efforts to enhance the performance of traditional devices such as resistive metal oxide sensors, is underway through nanoengineering. One of the novel properties of these semiconducting nanoparticles is having a very large surface to volume ratio. Among the various metal oxides, SnO_2 is the most attractive materials used for gas sensing applications. Since the gas sensing properties are strongly dependent on the surface of the materials exposed to gases, the sensor based on thin film nanostructures of metal oxide materials are expected to exhibit better properties than bulk. Also, development of the gas sensor device and its implementation in pollution monitoring system is not much studied. Considering the above facts into account efforts have been taken to synthesize pure and Al-

doped SnO_2 thin films. This report describes the structural, morphological, optical, and gas sensing properties of nanocrystalline tin oxide thin films synthesized by sol-gel spin coating method. An attempt is also made to develop a microcontroller based CO gas monitoring system which is portable, cheap and easy to implement.

In summary, pure and Al-doped SnO_2 thin films were prepared using sol-gel spin coating technique. The X-ray diffraction patterns show broad peaks indicating ultrafine nature of the particles in the thin films. The synthesized samples are pure tin oxide with tetragonal structure and Al-atoms are homogeneously incorporated into the tin oxide matrix. For pure SnO_2, the lattice parameters are a=4.7284Å and c=3.2673Å. Not much change is observed in the lattice parameters with Al-doping concentration. The average crystallite size for pure SnO_2 is 6.6 nm and decreases with increase in Al-doping concentration. SEM studies show that growth of the film takes place with porous structure embedded with nanogranules, increasing the open surface area of the film. Optical study revealed that band gap of SnO_2 is 3.96 eV with direct band to band transitions and increases with Al-doping concentration.

Gas sensing properties of the Al-doped SnO_2 thin films were systematically investigated and compared with those of the pristine SnO_2 thin films. Obtained results showed that the Al-doped sensor had a good selectivity to CO with much higher responses compared with the undoped sensor. The enhanced sensor response is due to small crystallite size, modifications in the electron Debye length and modifying the gas-surface interactions due to the formation of localized p-n junctions between the p-type Al-SnO_2 and n-type SnO_2. This work also suggests that the Al-dopant can be a promising substitute for the noble metal additives such as Ag, Au, Pt and Pd to fabricate chemical sensors with a much lower cost.

Employing embedded technology based on ARM7 LPC2148 microcontroller, a portable system is designed and implemented for CO gas monitoring. On inspection of the results, it is found that the data given by the sensor node is accurate. The RF module Zigbee operated at 2.4GHz ISM band really help for secure data transmission. The CO gas can be continuously observed on the monitor of the monitoring system. Thus, any one could get the concentration of Co gas in the environment, which could be helpful for further analysis. This system provides quick response rate and works with great reliability. The system can be modified for sensing more than one gas using array of sensors for various gases.

Dr. G. S. Shahane