Abstract

The need for simple and inexpensive gas sensors to control the quality of environment and to improve the economics of industrial processes has given rise to a wide variety of solid state sensing devices. Over the past few years, a great deal of research efforts have been directed towards the development of miniature gas sensing devices for domestic applications, toxic gas detection and manufacturing process monitoring etc. Many industrial gases have become increasingly important as raw materials and therefore for this reason it has become very important to develop a highly sensitive gas detector.

A large volume of literature is available on gas sensing materials, their processing and applications. In spite of that there is enough scope for study on the processing of sensor related materials and improvement in performance of gas sensors. Nature of material, crystallite size, morphology, additives etc. are some of the important parameters which effect the performance of a gas sensor. In case of pure materials, crystallite size and morphology play a crucial role in controlling the sensor behaviour.

In this thesis work, my prime aim is to synthesize the various morphologies of ZnO for improving its gas sensing characteristics. More specifically in this work I have tried to alter the morphology of ZnO nanostructures, by varying various parameters such as reaction temperature, sintering temperature, pH of the solution, precursor solution and surface activation of oxide material.

The focus of initial study was to synthesize zinc oxide nanostructures at various reaction temperatures. The effect of sintering on nanostructure growth has also been investigated. The material characterization results clearly indicate that the formation of zinc oxide nanorods and nanoparticles depends on reaction temperature. The sensors fabricated out of these powder indicated their response to be dependent on morphology and particle size.

Interesting results have been obtained by varying pH of precursor solution. Nanorods have been morphed into nanoparticles by varying pH of the solution from pH 8 to pH 11. At pH 8 to pH 10 nanorods of different dimensions have been formed however at pH 11 these nanorods completely changed to nanoparticles. It is found from this study that the sensing behaviour is different for different morphologies of ZnO and it has been verified that nanoparticles are more sensitive than nanorods of ZnO.

In another experiment I have investigated the effect of precursor viz. zinc nitrate, zinc chloride and zinc acetate on the morphology of zinc oxide. By
changing precursor solution I have observed that nanorods morphed into hexagonal prism geometry. I have also investigated the sensing behaviour of synthesized morphologies. Among all precursor solutions, zinc acetate assisted morphology has been found to be more favourable for gas sensing application.

The nanorods synthesized at room temperature in the first experiment were subjected to the 100 MeV of O$^{7+}$ ions at different fluences. The effect of swift heavy ion has been investigated on the sensing behaviour of the zinc oxide nanorods. In this investigation, it was found that sensing behaviour is stable after irradiation.

In the last experiment of the present thesis, surface of zinc oxide nanorods has been activated with different percentage of tin oxide. With this activation I have found a change in its morphology which enhances its effective surface area and hence gas sensing response significantly.