NANOSTRUCTURED SEMICONDUCTOR OXIDE POWDERS AND THIN FILMS FOR GAS SENSORS

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Semiconductor oxides such as SnO_2, TiO2, WO_3, ZnO_2 etc. (having carrier concentration ≈ 10^{16}-10^{19} cm^{-3}; band gap ≈ 2-4 eV and electron mobility ≈ 100 cm^2 V^{-1} s^{-1}) have been shown to be useful as gas sensor materials for monitoring various pollutant gases like H_2S, NO_x, NH_3 etc. [1-4]. The desirable factors of the good sensor are; high sensitivity, high selectivity and short response and retracing times. Of these, the sensitivity of a sensor can be maximized by maximizing the surface area of the material as the gas sensor action of semiconductor oxide being a surface phenomenon. Therefore, there is a trend to maximize the specific surface area of the particle (by reducing the average grain size) is seen from the literature using different chemical routes.

On the other hand, sensors with short response and retracing times can be achieved by maximizing the surface area to volume of the material which is better accomplished in thick or highly porous bodies made of Nanocrystallites. The engineering of complex oxide surfaces for chemical sensors, that is, the control of geometric and electronic structures of surfaces at the atomic scale can be achieved in thin film structures. Hence, the development of deposition techniques for processing the films consisting of interconnected crystallites together with high surface area to volume ratio has been the goal of our recent investigations. . Recently, Pulsed Laser Deposition (PLD) has been demonstrated to be a promising technique in terms of exact transfer of target stoichiometry on to the films.

In this work, we have attempted to investigate gas sensor characteristics of films having grains predominantly oriented in a particular direction by growing the films on appropriate substrates The targets for preparing SnO_2, InO_2, and TiO_2 thin films by PLD were made as follows: SnO_2 powders were first dried in air and then calcined at 1000°C for 24 hr. Finally, the product was compacted into pellets of 10 mm diameter and 3-5 mm thickness and sintered at 1000°C for 48 hr. A Lambda Physik Pulsed Excimer Laser (KrF; λ=248 nm) operating at 10 Hz was used. During the growth of the film, oxygen pressure of about 200 mtorr was maintained inside the chamber. After the deposition, the substrate was cooled at the rate of 25°C/min in oxygen ambient. Thin film preparation parameters such as substrate temperature, laser pulse energy and target-substrate distance were varied. The optimized in-situ conditions are: fluence-3J/cm^2; substrate-target distance-4.5 cm and temperature-500 to 700°C. Films were deposited on polycrystalline alumina and polished <100> $LaAlO_3$.

Crystallographic phase analysis was done by powder XRD technique. The surface morphology of these films were studied using atomic force microscopy (AFM). Electrical conductivity of thin films as a function of temperature were measured by impedance technique (Solartron impedance Analyser) using a specially designed cell for mounting thin films. Studies were performed in H_2, O_2 and air respectively flowing at the rate of 20 cc/min.

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References:

1. K.I.Gnanasekar, Kevin C. Langry, B. Rambabu, Journal of Electrochemical Society , 149(1) H19-H27, (2002)
2. K.I.Gnanasekar, B. Rambabu and Kevin C. Langry, Eur.Phys.J. AP 18, 9-15 (2002)
3. B. Rambabu Journal of Nanoscience and Nanotechnology, Vol 2; No 2, 2002
4. K.I.Gnanasekar, J.C.Jiang, Eddy Fannie Possey, and B. Rambabu, J. Mater. Res. 2002