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Abstract

With ever increasing pollutants in our ambience, there is an imperative demand for reliable and cost effective sensors for monitoring them. This need has motivated the author to carry out the research in this very direction using smart materials. In this thesis, author has synthesized nanocrystalline tin oxide powders. After characterization of these materials they were deployed as thick film sensors. Gas sensing is a complex surface phenomenon based upon the change in the resistivity of the metal oxide semiconductors. From the extensive literature review author found that there are many parameters upon which sensing phenomenon depends. So, while formulating the problem it has been kept in the mind that only one parameter be varied and it’s effect on the sensing response be observed keenly. In this thesis author has tried to control particle size of the nanocrystalline tin oxide powder and thus trace a correlation between particle size and sensing response.

Instrumentation of the sensor testing gadgets and equipments play a crucial role in solving the problem. The sensor testing chamber was designed and developed indigenously in the lab. The resistivity of semiconductor metal oxide based sensor falls in jiffy when exposed to the reducing agent. To alleviate this problem efficient and reliable data acquisition system is must. An operational amplifier based circuit was designed and abrupt change in the conductivity was recorded through this circuit by free software. The results recorded by this circuit and software are in agreement with the results obtained by Keithley data acquisition card.

In the very first attempt to synthesize nanosized tin oxide powder liquid phase crystallization technique was employed. The precipitates obtained were allowed to sediment for 4 hrs and after drying precipitates were sintered at $500^\circ C$. The powder was characterized by using XRD, SEM and TEM. The theme of this project being to control the particle size, slight variation in the formerly followed methodology was introduced. This variation was in the precipitate separation technique that is precipitates obtained were not allowed to sediment and were immediately centrifuged. Both these powders were deposited as thick films to behave as gas sensors. The sensing responses of these sensors were compared and results indicated that despite of similar particle size the powder synthesized by sedimentation have better response than the centrifuged powder.
Another technique used was the application of heat treatment at different stages of synthesis of powder. Reaction was carried out at different temperatures and then the resulting precipitates were sintered at different elevated temperatures ranging from 400-800 °C. All the powders were characterized for their material properties using XRD and TEM. Results obtained depicted the variation of the particle size with the heat treatment. At lowest reaction temperature the size of particles was the smallest. At room temperature we obtained the largest particles and further at higher temperature the particle was smaller. Sintering temperature also had detrimental effect on the particle size. The sensors fabricated from these powders were investigated for the response towards ethanol. The behaviour of these sensors was in fact in agreement with the theoretical assumptions, that is, smaller the particle greater the response.

The sensors synthesized from the SnO$_2$ powder with smallest particle size were subjected to the 100 MeV of O$^{7+}$ ions at different fluence rates. The material modification was on the cards XRD images clearly proved that. At lowest fluence rate there was decrease in the intensity of peaks. High fluence rate increased the intensity of peaks. The irradiation did not affect the particle size significantly. But when these sensors were exposed to ethanol we observed irradiation affected the sensing response significantly.

The selectivity of the sensor has also been dealt with. The technique of co-precipitation of zinc-tin was used to synthesize the nanocrystalline Zn-Sn composite oxide powder. The composite oxide powder obtained was sintered at different range of elevated temperature. The heat treatment once again showed its impact. The phases of composite oxide are dependant upon the sintering temperature as it is convincingly augmented by XRD graph. These phases have an important role in controlling the response towards test gases like ethanol and LPG.