ABSTRACT

The research work in this thesis entitled as **FABRICATION AND CHARACTERIZATION OF SOLID-STATE GAS SENSORS** is primarily focused on the development of gas sensing materials, their working principle, influence of defects inside the grains on sensor output, factors affecting gas sensor performance, their characterization by various methods like Scanning Electron Microscope, Powder XRD and their application towards the monitoring of tea quality. We also dealt with the band structure and its modification by the incorporation of defects. The shift of Fermi Level results an additional potential which affects the conductivity of gas sensor materials. The overall work delineated herein has been divided into five chapters.

The **Chapter I** covers a brief review on the recent fabrication procedure of gas sensing materials, transition metal oxide semiconductor gas sensors, their characterization, various gas sensing mechanism that includes potential barrier model, band bending model etc which deals with the surface of the grains, effect of doping, effect of microstructure, particle size on the sensor performance and finally application of these gas sensor materials in various fields.

Chapter II depicts the study of the responses with temperature of a p-type, La_2CuO_4 and a n-type, WO_3 semiconducting sensing element fabricated over YSZ substrate in NO gas atmosphere. The measurements in potentiometric and resistive modes revealed that for potentiometric mode the peak of the response curve shifts toward lower temperature region and for resistive mode the peak shifts towards higher temperature region which confirms more sensitivity of potentiometric mode at lower temperature region compared to resistive mode for both kind of sensing materials.

Chapter III illustrates the detection limit of solid state gas sensors are dependent on the size and average pore diameter of the sensing material which can be varied by sintering the materials at appropriate temperatures. In this paper, we report the fabrication and characterization of a potentiometric NO_x gas sensor based on La_2CuO_4 nanoparticles as efficient electrode material annealed at different temperatures. The synthesized nanoparticles were characterized by

scanning electron microscopy (SEM) and X-ray diffraction (XRD) which revealed that the particle size of the prepared nanomaterials increases with increasing the sintering temperature. It was observed that the smaller nanoparticles increases the contact surface area of the gas–solid interface and exhibited higher sensitivity at low gas concentrations. From voltage response curve, it has been observed that range of detection was maximum at intermediate particle size diameter and became least at large diameter nanoparticles. Planar sensor elements were fabricated over tape cast YSZ substrate with both the ceramic and metal electrodes screen printed on either side of the substrate. The dependence of sensitivity at different range of gas concentration with the pore size distribution of the sensing electrode has been studied in this investigation.

In **Chapter IV** the mechanism of NO adsorption on the WO_3 surface to improve the performance of gas sensing has been studied from a theoretical view point based on Density Functional Study. Different activation energies of the defect directly affect the surface chemistry of the sensing material. Here, the adsorption behaviour of NO on the sensor surface, including the perfect and WO_3 surfaces with defects have been studied. In this study it was revealed that surface oxygen vacancies induced by the adsorption of NO molecule on the defect free WO_3 surface increased the surface conductance of the sensing material. The WO_3 surface with defects was re-oxidized by the atmospheric O_2 molecules. During this step, charge transfer from the surface to O_2 molecule generates an active O_2 species which results in reduction of surface conductivity. This active O_2 species tends to react with the NO molecule and releases NO_2 molecule with the reproduction of perfect WO_3 surface. The difference between Fermi levels associated with above surface reactions were determined with the help of Density Functional study and was found to be 1.54 eV.

In **Chapter V** we have prepared various transition metal doped ZnO nanosensing material which have been successfully used to sense the flavor of Orthodox Darjeeling tea collected from various garden by electronic nose system. The application of E-nose system to determine tea quality is a new direction of research to develop better sensing material. Doping is a very good process which can modify the response signal of E-nose system to a better one. Research in this ground will significantly increase the quality of the sensor system which will obviously help to better differentiate the quality of various teas, foods etc.