ABSTRACT

The research work embodied in this thesis reports a comprehensive piece of experimental work that demonstrates development of automated highly sensitive and selective gas sensing system for air quality monitoring. Synthesis of pure and composite structure of nano-crystalline spinel ($NiFe_2O_4$ and $Mg_{0.5}Zn_{0.5}Fe_2O_4$): perovskite ($La_{0.8}Pb_{0.2}Fe_{0.8}Co_{0.2}O_3$) nano-structures of various morphologies such as nano powder (0d), nanotube (1d) and thin film (2d) were done through wet chemical synthesis method. Additionally, thin film structure of binary oxide (WO_3) was also synthesized through sol-gel route. The synthesized materials were characterized in terms of their phase formation, optical property, spectroscopic information, N_2 adsorption-desorption isotherm analysis, electrical property and different toxic, inflammable and organic vapors sensing study. Wherever applicable the interrelation among these properties with gas sensing was discussed. The improvement in sensing parameters were related with small grain size, wide pore size distribution, encapsulation/core-shell effect, spectroscopic nature, electro-catalytic property, percolation activity and p-p/ n-p iso/diode like hetero-interface formation in the composite system. For environmental air quality monitoring, highly sensitive and selective toxic gas sensors are required. We have optimized the best materials suitable for selectively sense CO, C_4H_{10} and NO_2. The array of response transient output of three sensors were further processed with various signal processing techniques (such as FFT, DWT) in conjunction with various pattern recognition techniques (PCA, tree analysis) which helps to discriminate all gases and gas mixtures qualitatively and quantitatively. Special features such as carrier type alternation during gas sensing was identified and explained through reaction kinetics analysis. A microcontroller (AVR ATMEGA) based low cost and portable static gas sensing set up (integrated with heater control, humidity measurement, data acquisition with laptop) was also developed to monitor various toxic, inflammable gas and volatile organic compounds in real time. The software of the microcontroller, signal processing strategies and statistical classification techniques were developed in C programming. Drift is a severe concern for ceramic gas sensor. Therefore, a time-window based continuous standard deviation or slope measurement was also developed to avert the false alarming. The developed prototype was also tested in various real time environments in order to test the functionality of the materials and device.

Keywords: Wet chemical sol-gel synthesis; Spinel-perovskite composite; Selectivity; Toxic gas sensing; Air quality monitoring; Microcontroller.