Abstract

We have optimized various process parameters to synthesize CuO, $LaFe_{0.8}Co_{0.2}O_3$ (LFCO), ZnO (Z), LFCO – ZnO (LZ) composite, LFCO/ZnO (L/Z) and CuO/ZnO (C/Z) bilayer p-n heterojunction thin films using chemical solution deposition route. We have studied the ethanol and acetone sensing characteristics of CuO thin film and applied the gas diffusion theory to p-type CuO thin films of thickness 120-288 nm. We found that the gas response first decreased with increasing thickness and subsequently exhibited a volcano-shaped behaviour with further increase in film thickness for CuO thin films. We have developed the LFCO thin-film sensor for selective CO sensing applications assuming the efficient catalytic activity of the LFCO perovskite surface and the skillful microstructural control of thin-film morphology. We found that for film thickness in the range 92 – 432 nm, the 243 nm thin film exhibited the maximum response % to CO at 225°C and was also selective to CO in the studied temperature range. We have compared the CO and CO_2 sensing behaviour in LZ composite and L/Z p-n heterojunction bilayer thin films. We found that the LZ composite thin film is sensitive to both CO and CO_2 over a wide temperature range of 150-350°C whereas the L/Z sensor is selective to CO_2 between 150 and 300°C. The cross-sensitivity of CO and CO_2 in the LZ sensor was addressed via principal component analysis (PCA) of the resistance transients and simulation of conductance transients. The selectivity to CO_2 in the L/Z sensor is attributed to the formation of a p-n heterojunction between LFCO and ZnO. We have also studied the adsorption characteristics of CO_2 and C_4H_{10} gases on the C/Z sensor surface. We found that CO_2 follows the extended Freundlich model whereas C_4H_{10} obeys the extended Langmuir model of adsorption. From theory, we have calculated the activation energy, E_A and heat of adsorption, Q for the test gases. These values for CO_2 and C_4H_{10} are found to vary considerably in the range of concentrations studied. We have also fabricated a portable and economical gas-sensing prototype. The efficiency of the prototype was tested in the laboratory as well as in the field.

Keywords: Thin film gas sensor, gas diffusion theory, CO sensing, CO_2 sensing, adsorption theory, portable sensing prototype