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Electrodeposited metal sulfide thin films for gas sensing applications

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Quantitative measurements of gases are based on a variety of physical or chemical principles. Among them semiconductor gas sensors are best candidates for the development of commercial gas sensors due to their higher specificity and sensitivity. They are mainly based on metal oxide and metal sulfide materials. Due to certain drawbacks of metal oxides, metal sulfides are extensively investigated as novel gas sensing materials. In this study ZnS and CdS were investigated for their gas sensing ability. Both types of thin films were fabricated by electrodeposition using a three electrode electrolytic system consisted of a fluorine doped tin oxide glass substrate (1×3 cm^2) as working electrode and a high purity carbon as counter electrode. An aqueous electrolyte containing $CdCl_2$ (0.10 mol/L) and $Na_2S_2O_3$ (0.01 mol/L) precursors were used for the electrodeposition of CdS material and aqueous electrolyte containing $ZnCl_2$ (0.10 - 0.05 mol/L) and $Na_2S_2O_3$ (0.01 - 0.05 mol/L) precursors were used for electrodeposition of ZnS material. The CdS depositions were carried out in the cathodic deposition potential (CDP) range of 0.65 to 0.70 V vs. saturated calomel electrode and pH range of 1.5 to 2.0 at a temperature of 55 °C for 30 minutes. The ZnS depositions were carried out in the CDP range of 0.70 to 1.10 V vs. Ag/AgCl reference electrode and pH range of 4.0 to 3.5 at a temperature of 30 °C for 90 minutes. Both types of thin films were characterized for their crystalline structure, surface morphology, and elemental composition by using the techniques of X-ray diffraction spectroscopy, scanning electron microscopy, energy dispersive X-ray spectroscopy respectively and were exposed to various gases namely; NO_2, H_2S, and LPG. CdS thin films grown at CDP of 0.67 V and pH of 1.5 and ZnS thin films grown at CDP of 1.05 V and pH of 3.7 were found to have notable gas sensing properties. CdS has shown highest resistance variation of 1.2 Ω towards H_2S with respect to the initial resistance of 36.0 Ω and ZnS has shown highest resistance variation of 2 Ω with respect to the initial resistance of 26.2 Ω when exposed to NO_2 gas at 30 ºC. Both CdS and ZnS thin films showed resistance variation of 1.1 Ω and 0.6 Ω towards LPG respectively at 30 ºC.

Keywords: Electrodeposition, Metal sulfides, CdS, ZnS, Semiconductor gas sensor

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