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Highly sensitive and room-temperature operable carbon dioxide gas sensor based on spin-coated Sn-doped Co_3O_4 thin films with advanced recovery properties.

Rana Saad, Khaled Abdelkarem, Mohamed Shaban, Adel M. El Sayed, Inas A. Ahmed, Mohamed T. Tammam, Hany Hamdy

Abstract

The urgency to address climate change has highlighted the need for gas sensors capable of monitoring air quality at room temperature (RT) and accurately measuring the concentrations of carbon oxides (CO_2 and CO) in the environment. This study details the development of a highly sensitive CO_2 gas sensor using spin-coated Sn-doped Co_3O_4 thin films, operating at a room temperature of 30ºC and a relative humidity (RH%) of 43 %. Extensive characterization employing XRD, SEM, EDX, FTIR, and UV–Vis optical techniques verified the impact of Sn doping on the surface morphology, phase purity, and a notable reduction in the dual-band gap of the thin films. Gas sensing measurements were conducted at RT using varying CO_2 gas concentrations. A sensor response of 796.81 % was obtained for the optimally sensitive film, 10 % Sn-doped Co_3O_4, at a CO_2 concentration of 9990 ppm. Additionally, a range of RH % levels was examined at a constant CO_2 gas concentration of 9990 ppm, revealing an optimal humidity level of 43 % at RT. Further analysis revealed that the 10 % Sn-Co_3O_4 sensor displayed enhanced sensitivity to CO_2, surpassing its response to N_2, H_2, and NH_3 gases. The determined limits of detection and quantification underscore the sensor's precision and reliability in quantifying CO_2 gas concentrations. Our findings demonstrate the excellent potential of Sn-doped Co_3O_4 thin films as highly sensitive CO_2 gas sensors. These films provide a promising solution for detecting elevated CO_2 levels at room temperature, aiding climate change mitigation efforts.

Keywords: Co_3O_4 thin films; CO_2 sensing; Dual bandgap; Sensor response; Selectivity; Room temperature; Relative humidity