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Gas sensing performance of pristine and modified Ga2O3 nanostructures for environment monitoring and food safety

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The release of toxic gases from modern industries seriously threatens the environment and human safety [1,2]. Many researchers are therefore committed to developing inexpensive and effective sensors for detecting and monitoring such gases using semiconductor metal oxide (SMO) nanostructures [3]. In this work, a series of studies were conducted to investigate the gas sensing performance of unmodified and noble-metal-modified Ga2O3 nanorods prepared using a microwave-assisted hydrothermal method followed by heat treatment. Variation in the heat-treatment temperature induced controlled polymorphism, morphology, and structural defects in Ga2O3. The gas sensing measurements revealed a highly selective response, fast response (45s)/recovery (42s) times, and low detection limit of 0.61 ppm towards CO for the β-Ga2O3 sensor at a working temperature of 165 ℃. The β-Ga2O3 outperformed the α-Ga2O3 and α/β-Ga2O3 polymorphs due to more active surface sites offered by the high surface area and controlled donor and acceptor defects such as VGa and VO, respectively, for improved surface-target gas interaction. The decoration of β-Ga2O3 nanorods surfaces by 1mol% of noble-Ag nanoparticles demonstrated an optimum response coupled with a fast response/recovery time of 38/60 s towards ethylene gas at a lower working temperature of 140 ℃. DFT calculations and experimental characterizations revealed that high ethylene sensing benefited several factors including higher adsorption energy of ethylene compared to other target gases, sensitization and catalytic effects of surface plasmonic Ag metals, high surface area and high concentration of defects related to VO and VGa thus offering more active sites for surface-gas interaction. This work demonstrates the potential CO and ethylene sensing capabilities by unmodified β-Ga2O3 and 1mol%Ag-modified β-Ga2O3, respectively. Ethylene detection is important in food safety−quality monitoring and control in the fruit supply chains [4].

Keywords: Ga2O3; polymorphism; noble metals (Ag, Au); carbon monoxide; ethylene; gas sensing.

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