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Research Article

Adsorption of Hydrogen Sulfide on Reduced Graphene Oxide-Wrapped Titanium Dioxide Nanofibers

Kanchit Kamlangkla,[1] Aphichard Phongphala,[1] and Udomdej Pakdee [1,2]

[1]*Division of Physics, Faculty of Science and Technology, Rajamangala University of Technology Krungthep, Bangkok 10120, Thailand*
[2]*Division of Energy Technology for Environment, Faculty of Science and Technology, Rajamangala University of Technology Krungthep, Bangkok 10120, Thailand*

Correspondence should be addressed to Udomdej Pakdee; udomdej.p@mail.rmutk.ac.th

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This work presents a fabrication of room-temperature gas sensor for hydrogen sulfide (H_2S) adsorption. Pristine titanium dioxide (TiO_2) nanofibers, reduced graphene oxide (rGO) sheets, and reduced graphene oxide-wrapped titanium dioxide (rGO-wrapped TiO_2) nanofibers were presented in the form of integrated suspension used for a gas-sensing layer. The TiO_2 nanofibers were firstly synthesized by using an electrospinning method with a polyvinylpyrrolidone (PVP) polymer. The rGO sheets were then wrapped around TiO_2 nanofibers by a hydrothermal method. Scanning electron microscope, transmission electron microscope, X-ray diffractometer, and Raman spectrometer confirmed the presence of rGO sheets onto the surface of TiO_2 nanofibers. Ultraviolet-visible spectrophotometer was also considered and displayed to calculate the band gap of TiO_2 and rGO-wrapped TiO_2 nanofibers. After preparing the gas-sensing suspensions, they were dropped onto the polyethylene terephthalate substrates with silver-interdigitated electrodes. The gas-sensing properties of sensors were evaluated for H_2S adsorption at room temperature. Based on the results, the rGO-wrapped TiO_2 nanofiber gas sensor exhibited higher H_2S sensitivity and selectivity than pristine TiO_2 nanofiber and pure rGO gas sensors. The H_2S-sensing mechanism of rGO-wrapped TiO_2 nanofiber gas sensor was discussed based on a formation of p-n heterojunctions between p-type rGO sheets and n-type TiO_2 nanofibers. Furthermore, a direct charge-transfer process by physisorption was also highlighted as a second H_2S-sensing mechanism.

1. Introduction

Hydrogen sulfide (H_2S) is an extremely harmful and flammable gas. It smells like rotten eggs at low concentration in the air. The harm of H_2S is dependent on its concentration and exposure time. A short-term exposure to over 500-1000 ppm of H_2S is immediately fatal [1]. Repeated exposure to H_2S in concentrations even 10-500 ppm can cause serious damage to organs and central nervous system [1–3]. Therefore, the sensor for the detection of H_2S is required to be developed with high sensitivity and fast response at low concentration. In the past several decades, the metal oxide semiconductor (MOS) nanostructures have become one of the popular materials in gas-sensing applications. The MOS gas sensors have been led to the adsorption in toxic gases [4–6]. However, the adsorption of most H_2S needs to operate at high temperatures [7, 8], although some types of MOS gas sensors can be operated at room temperature under the influences of humidity [9–13]. The MOS provides a large number of free electrons in the conduction band and oxygen vacancies on the surface of the metal semiconductors, resulting in strong adsorption characteristics and high reactivity on the surface of gas molecules [14–17]. Among various MOS materials, titanium dioxide (TiO_2) and its composite have been reported as a popular material for applications in lithium-ion storage [18, 19] and photoelectrocatalysis [20–22]. Due to its strong oxidizing power, abundant existence in nature, nontoxicity, and long-term