Sensors & Actuators: B. Chemical 364 (2022) 131905

Contents lists available at ScienceDirect

Sensors and Actuators: B. Chemical

journal homepage: www.elsevier.com/locate/snb

PdO and PtO loaded WS_2 boosts NO_2 gas sensing characteristics at room temperature

Aanchal Alagh [a], Fatima Ezahra Annanouch [a,*], Khaled Al Youssef [b], Carla Bittencourt [b], Frank Güell [c], Paulina R. Martínez-Alanis [c], Marc Reguant [c], Eduard Llobet [a]

[a] Departament d'Enginyeria Electronica, Universitat Rovira i Virgili, avenida Països Catalans 26, 43007 Tarragona, Spain
[b] Laboratory of Plasma-Surface Interaction Chemistry (PSI Chem), University of Mons, Av. Nicolas Copernic 1, 7000 Mons, Belgium
[c] ENFOCAT-IN2UB, Universitat de Barcelona, C/Martí i Franquès 1, 08028 Barcelona, Catalunya, Spain

ARTICLE INFO

Keywords:
TMDs
Functionalization
Gas sensors
CVD
AACVD
Tungsten disulphide

ABSTRACT

In this work tungsten disulphide nanostructures loaded with platinum-oxide (PtO), or palladium-oxide (PdO) were grown directly onto alumina substrates. This was achieved using a combination of aerosol-assisted chemical vapour deposition (AA-CVD) method with atmospheric pressure CVD technique. At first, tungsten oxide nanowires loaded with either PtO or PdO nanoparticles were successfully co-deposited via AA-CVD followed by sulfurization at 900 °C in the next step. The morphological, structural, and chemical characteristics were investigated using FESEM, TEM, XRD, XPS and Raman spectroscopy. The results confirm the presence of PdO and PtO in the WS_2 host matrix. Gas sensing attributes of loaded and pristine WS_2 sensors were investigated, at room temperature, towards different analytes (NO_2, NH_3, H_2 etc.). Both pristine and metal-oxide loaded WS_2 gas sensors show remarkable responses at room temperature towards NO_2 detection. Further, the loaded sensors demonstrated stable, reproducible, ultrasensitive, and enhanced gas sensing response, with a detection limit below 25 ppb. Additionally, the effect of ambient humidity on the sensing response of both loaded and pristine sensors was investigated for NO_2 gas. The response of PtO loaded sensor considerably decreased in humid environments, while the response for pristine and PdO loaded sensors increased. However, slightly heating (at 100 °C) the sensors, suppresses the influence of humidity. Finally, the long-term stability of different sensors is investigated, and the results demonstrate high stability with repeatable results after 6 weeks of gas sensing tests. This work exploits an attractive pathway to add functionality in the transition metal dichalcogenide host matrix.

1. Introduction

While technological advancements have improved an individual's lifestyle, they have also contributed to the emergence of environmental issues, such as global warming and pollution. In particular, the number of pollutant emissions in the atmosphere has increased dramatically, leading to air pollution [1]. This phenomenon is caused by particulate matter and several harmful gases, including nitrogen dioxide (NO_2), ammonia (NH_3), carbon monoxide (CO), sulphur dioxide (SO_2), hydrogen sulphide (H_2S), carbon monoxide (CO), and ozone (O_3) [2]. These gases not only pose a threat to the environment but are also detrimental to human health, as they are a leading cause of ailments such as respiratory irritation syndrome, lung diseases, and bronchitis, only to name a few. According to research, air pollution is responsible for one out of every nine deaths each year, making it the leading cause of death. Besides, around 92% of the world's population lives in areas with poor air quality, putting them at significant risk of premature death [3]. Furthermore, among all, NO_2 is one of the life-threatening contaminants. Therefore, the legitimate airborne permissible exposure limit of NO_2, as stipulated by the Occupational Safety and Health Administration (OSHA) is 5 ppm, which cannot be surpassed [4]. Also, the American Industrial Hygiene Association has set a 5-minute emergency exposure limit for NO_2 at 35 parts per million (ppm) as exposure above this concentration can cause skin damage and respiratory issues [5]. Therefore, it is now more important than ever to regularly monitor and evaluate the air quality.

In this respect, gas sensing devices play an essential role in the detection and monitoring of poisonous pollutants like NO_2 to reduce their damaging effects. Based on their working mechanism, these devices are categorised into chemoresistive, optical, electrochemical, and

* Corresponding author.
E-mail address: fatimaezahra.annanouch@urv.cat (F.E. Annanouch).

https://doi.org/10.1016/j.snb.2022.131905
Received 31 January 2022; Received in revised form 2 April 2022; Accepted 13 April 2022
Available online 16 April 2022