Sensors & Actuators: B. Chemical 351 (2022) 130947

Contents lists available at ScienceDirect

Sensors and Actuators: B. Chemical

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

Concentration modulated vanadium oxide nanostructures for NO_2 gas sensing

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ARTICLE INFO

Keywords:
Hydrothermal method
Vanadium oxide
NO_2 gas
Gas sensor

ABSTRACT

Vanadium Oxide (V_2O_5) nanostructures have been prepared via a simple and inexpensive hydrothermal method using ammonium metavanadate as a vanadium precursor along with oxalic acid. Present work demonstrates the effect of concentration (0.1–0.4 M) variation on gas sensing performance of hydrothermally prepared vanadium pentoxide. The structural, morphological, functional group, and optical properties of V_2O_5 nanostructure have been investigated by using different characterization techniques like X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Fourier Transform Infra-Red (FTIR) Spectroscopy, Raman spectroscopy, and Diffused Reflectance Spectroscopy (DRS) studies respectively. The structural analysis revealed orthorhombic V_2O_5 phase formation with the c-axis orientation along (001) plane. The SEM images revealed platelet-like nanostructures, agglomerated nano structure, and clusters of elongated nano structure. The variation in band gap from 2.06 to 2.14 eV is observed with a change in precursor conc. The BET study indicates good specific surface area and optimum pore diameter. The Photoluminescence shows a centered peak arising at characteristic wavelength 709.25 nm and some other peaks observed at 540.91 nm, 470.86 nm and 391.50 nm which is good for gas sensing application. The sensing selectivity was high for NO_2 gas detection at 150 °C. All samples revealed good response with fast response and recovery time. Sample prepared with 0.3 M concentration exhibited the best response attributed to optimum pore size and high surface area which governs superior sensing features. The response of V_2O_5 is found to be 13% towards 100 ppm NO_2 gas, while response and recovery time is 4 and 55 s respectively. The present work depicts the results of NO_2 gas sensing with fast response and recovery time at relatively low working temperature (150 ℃). Hence it explores the use of this material as a potential candidature for the fabrication of vanadium oxide-based gas sensors.

1. Introduction

In recent years, due to vast industrialization and vehicle transportation air pollution in urban as well as in rural areas increased drastically. Such poisoning atmosphere creates serious problems to the respiratory system of a human being [1]. Nowadays many countries facing the problem regarding air pollution. Clean air is a major requirement of all countries, and its supply is essential to our health and the environment. The human nose serves as an advanced sensing system that may differentiate between hundreds of smells but fails if absolute gas concentrations or odorless gases. So there is a need for gas detection. The demand for detecting toxic and deleterious gases is accordingly urgent to support or replace the human nose [2]. In today's world, the demand for developing simple yet reliable gas sensors is huge for the application in areas such as environment monitoring, agriculture, medical diagnosis, and industrial wastes. The detection of gas molecules such as nitrogen dioxide (NO_2), ammonia (NH_3), Carbon monoxide (CO), etc is necessary [3]. Out of all toxic gases, NO_2 is evolved in a tremendous amount from the industrial sector and vehicle transportation. Apart from these sources, NOx and SOx is also evolved from coal fire plant which creates acid rain, global warming and smog [4]. In the field of nanotechnology, the advancement still continues which

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https://doi.org/10.1016/j.snb.2021.130947
Received 7 July 2021; Received in revised form 19 September 2021; Accepted 14 October 2021
Available online 19 October 2021