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Abstract

WO3-Pt/Graphene Nanocomposite Sensors for Methane Sensing Applications †

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Abstract: This study presents the fabrication and characterization of chemoresistive sensors based on a nanocomposite of WO3-Pt and graphene for methane detection. The graphene was prepared using a liquid-phase exfoliation technique, and the nanocomposite was deposited onto interdigitated gold electrodes using drop-casting. The response of the sensors was analyzed by measuring changes in electrical resistance at methane concentrations of 7, 5, 3, and 1 ppm.

Keywords: graphene; MOS; chemi-device; gas sensor; methane

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1. Introduction

Methane is a significant greenhouse gas and a crucial component of natural gas, widely used as a fuel source [1]. Hence, developing efficient sensors for its detection is essential for environmental monitoring. Nanotechnology-based materials have shown promise for such sensing applications. Graphene is a desirable material due to its high responsiveness to conductivity changes when exposed to variations in the density of states and external gases [2]. However, its pristine state cannot differentiate between gas species and tune sensitivity due to the absence of a definite band-gap [3]. To enhance gas sensing capabilities, the use of hybrid structures made by combining metal or metal- oxide nanoparticles with graphene has been explored. This study focuses on the fabrication and characterization of chemoresistive sensors based on a nanocomposite of WO3-Pt and graphene for methane detection, which have shown great potential in terms of sensitivity, selectivity, and stability.

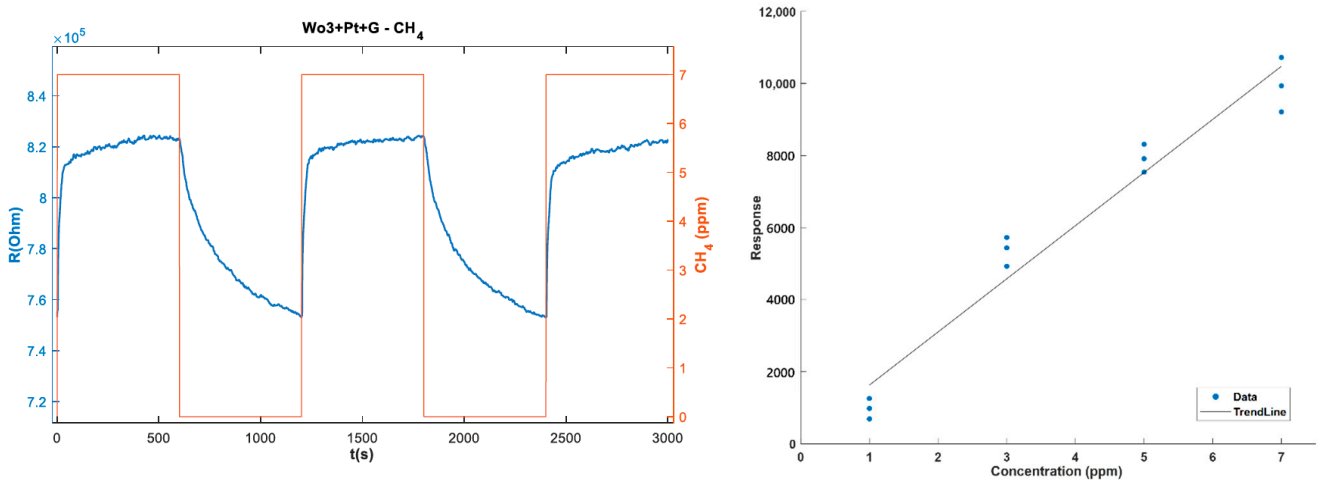
2. Materials and Methods

The synthesis of nanocomposites of graphene with WO3-Pt was performed using nanoparticles of WO3 (<100 nm), nanoparticles of Pt (~5 nm), and pristine graphene in a hydroalcoholic solution. The graphene solution was generated using a liquid-phase exfoliation technique, as described in [4], which involved dispersing graphite flakes (Sigma-Aldrich, St. Louis, MO, USA) in a mixture of IPA and H_2O (1:7, *v*:*v*), followed by sonication at low power (~30 W) for approximately 48 h. The mixture was then centrifuged for 45 min at 500 rpm to remove the non-exfoliated graphite crystals. The Pt nanoparticles were mixed with the WO3 nanoparticles in a mass ratio of 1%. Then they were combined with the graphene solution in a mass ratio of 0.7%, followed by sonication for one hour to promote intimate contact between the components. The material was deposited onto interdigitated gold electrodes (10/10 µm, electrode/gap) with a radial design using the drop-casting technique and then subjected to thermal treatment at 250 °C for one hour.

The chemoresistive sensor response was analyzed by placing it in an airtight chamber and measuring changes in electrical resistance at methane concentrations of 0 and 7, 5, 3 and 1 ppm (three repetitions for each concentration). Methane was generated using calibrated cylinders with a constant flow rate of 100 mL/min, at 30% RH, and the measurements were obtained using a digital multimeter (Keithley, Cleveland, OH, USA). The adsorption and desorption cycles were conducted for 10 min each. The sensor was UV irradiated during the methane flow.

3. Discussion

Figure 1 shows the resistive behavior of the material to changes in methane concentration (0–7 ppm), where the response appears to be reversible. The characteristic values (mean resistance to methane—mean resistance to clean gas) are also shown. Methane can be detected even at concentrations of 1 ppm, although the response drops significantly.



(**a**) (**b**)

Figure 1. Resistive behavior of the material to changes in methane concentration (**a**) dynamic response to 7 ppm steps; (**b**) difference in the characteristic values for each measurement and the characteristic value at 0 ppm concentration.

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