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FLUORINATED CARBON NANOHORNS – BASED NANOCOMPOSITE AS SENSING LAYER FOR RESISTIVE NITROGEN DIOXIDE SENSOR

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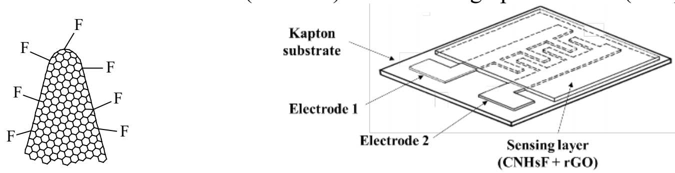
Introduction

Nitrogen dioxide (NO_2) resistive sensors are devices used to detect the presence of nitrogen dioxide gas in the environment commonly employed in various applications, including air quality monitoring, industrial safety, and automotive emissions control. NO_2 is one of the nitrogen oxides (NOx), which are harmful air pollutants. Inhalation of nitrogen dioxide can have serious health effects on humans. Short-term exposure to elevated NO_2 levels can cause respiratory problems, including irritation of the respiratory tract, coughing, and difficulty breathing, and can exacerbate pre-existing respiratory conditions such as asthma and bronchitis. Extremely high levels of exposure (above 150 ppm for 30 min to an hour) can be fatal. Furthermore, long-term exposure can contribute to the development and worsening of chronic respiratory diseases, cardiovascular diseases, and can even have detrimental effects on the nervous system. NO_2 is also a contributor to environmental problems, including the formation of ground-level ozone and acid rain. Due to the severe health risks associated with nitrogen dioxide, monitoring and controlling its levels in the air is essential for public health and environmental protection. This is where sensors and monitoring devices, such as the NO_2 resistive sensors mentioned earlier, play a critical role in detecting and mitigating the presence of NO_2 in various environments. Resistive sensors are known for their relatively low cost and simple design. They are used in air quality monitoring systems to detect and quantify NO_2 pollution, which is a common component of urban air pollution and a contributor to respiratory problems. These sensors are also employed in industrial settings to monitor NO_2 levels in workplaces, helping ensure worker safety. In automotive applications, NO2 sensors are used in exhaust systems to monitor and control emissions to meet environmental regulations. NO2 resistive sensors may have limited selectivity and can be sensitive to other gases, which can lead to false readings in certain conditions.

Sensor architecture

This paper reports a theoretical experimental setup for a resistive nitrogen dioxide sensor, using a sensing layer based on a binary matrix nanocomposite comprising fluorinated carbon nanohorns (CNHs-F) and reduced graphene oxide (rGO).



a) **b)**

Figure 1. a) Structure of fluorinated carbon nanohorns, and b) sensing device architecture

The sensing device consists of a metallic interdigitated dual-comb structure fabricated on a Kapton substrate with gold electrodes (Figure 1). They can be linear or have an interdigitated configuration. The NO_2 monitoring capability is investigated by applying a constant current between the two electrodes and measuring the voltage at different values of the NO2 concentration to which the sensing layer is exposed.

Advantages of the proposed sensing layer

It was demonstrated by numerous studies that fluorine functionalization of a sensing substrate for NO_2 (nitrogen dioxide) sensing is a technique used to enhance the performance of NO_2 gas sensors. Fluorine functionalization can enhance the sensitivity of the sensing substrate to NO_2 molecules, improve the selectivity of the sensor, stabilize the sensor's performance over time, reduce drift ensure consistent and reliable measurements, and accelerate the response time of the sensor. The interaction of NO_2 molecules with rGO and CNHs-F can be interpreted from the perspective of the HSAB theory. Both fluorinated carbon nanohorns and reduced graphene oxide. they are p-type semiconductors, conducting mainly through holes. When the sensitive layer is exposed, the physisorbed and chemisorbed molecules of NO_2 (oxidizing gas) will act as electron acceptors, increasing the concentration of holes in both nanocarbon materials and thus leading to a decrease in resistance. Fluorinated carbon nanohorns and reduced graphene oxide give a high specific surface/volume ratio, as well as a variation in the resistance of the sensitive layer upon contact with NO_2 molecules. The new synthesized sensing layer has several significant advantages: detection at room temperature, chemical and thermal stability, and superior mechanical properties.

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