Ammonia Sensing Using Multilayer Graphene Grown on Co-Ni/Al_2O_3 Substrate

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Abstract: Ammonia is widely employed in several industrial processes such as fertilizer, fire power plant, and food processing. Hence, it is expedient for the detection of ammonia in trace amount which necessitated the use of sensing materials. In this study, multilayer graphene grown on Co-Ni/Al_2O_3 substrate using Chemical Vapour Deposition at a temperature range of 700-800 ^oC was employed for gas sensing application at room temperature. The sensitivity of the multilayer graphene to the detection of different concentrations of ammonia as a function of time was investigated. The finding shows that the minimum sensitivity response of the multilayer graphene at 0.06% ammonia concentration was 7.29%, while the maximum sensitivity response of the multilayer at 1% ammonia concentration was 8.3%, which is an indication that the MLG film-based sensor has an affinity towards NH_3.

***Keywords*:** Ammonia, sensor, multilayer graphene, chemical vapour deposition, Cobalt-Nickel alloy

INTRODUCTION

Recently, multilayer graphene has gained wide application as a promising material for sensors, such as gas and biosensors. The application of multilayer graphene in gas or biosensing is based on its change in electrical conductivity (σ) as a result of the adsorption of gas molecules on its surface [1]. The variation in the conductivity of multilayer graphene is a result of the corresponding changes in the carrier concentration of the multilayer graphene caused by the absorption of gas molecules. In this case, the adsorbed gas molecules serve as donors or acceptors. The potential of multilayer graphene as a material for gas sensing applications is primarily due to its unique properties, whereby its sensitivity is increased to single-atom or molecular-level detection [2]. Multilayer graphene, as a two-dimensional (2D) material, has all its carbon atoms exposed to the analyte of interest during gas sensing applications. Moreover, the high conductivity of the multilayer graphene often results in low Johnson noise (electronic noise generated by thermal agitation of the charge carriers inside an electrical conductor at equilibrium, which occurs regardless of any applied voltage) [3].

MATERIALS AND METHODS

The multilayer graphene employed in this study was prepared and characterized as reported in Ali et al [4]. The setup for the gas sensing application of the multilayer graphene consists of a sample chamber containing the MLG-based sensor, a power source, a digital voltmeter ammeter for measuring the current at a fixed voltage, and a computer system with inbuilt software for measuring the concentration of the gases. Ammonia concentration ranges between 0.06 and 1% were used for

sensing experiment. Prior to the sensing application, 100% air was passed through the sensor chamber to ensure stability. The MLG-based sensor was exposed to different concentrations NH_3 for a period of 15 min at a fixed voltage of 1.5 V. The current of the MLG-based sensor device was measured over time at the stipulated fixed voltage. At intervals, the sensor chamber was degassed by passing 100% air through it for a period of 10 min before subsequent exposure to another concentration of the gas.

RESULTS AND DISCUSSION

MLG was tested as a sensing material for ammonia to investigate its sensing behavior towards the gas. Fig. 1. shows a plot of sensitivity versus time for different ammonia concentrations. Interestingly, the sensitivity increases with increased NH_3 concentration. The minimum sensitivity response of the multilayer graphene at 0.06% gas concentration is 7.29%, while the maximum sensitivity response of the multilayer graphene at 1% gas concentration is 8.3%, which is an indication that the MLG film-based sensor has an affinity towards NH_3. In a similar study by Gautam and Jayatissa [5] single-layer graphene synthesized on a Cu substrate by CVD using a mixture of CH_4 and H_2 as the carbon source was reported to have high sensing ability to 75 ppm (0.0075%) NH_3. This finding shows that relative changes in the sensor resistance agree well within 5% from one cycle of response and recovery to another cycle.

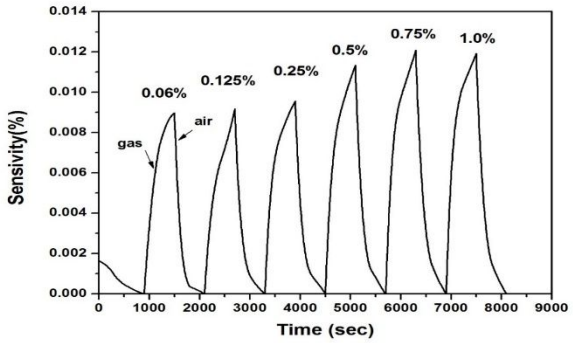

Fig. 1. The sensor response for different NH_3 concentrations at room temperature.

CONCLUSIONS

The gas sensing properties of MLG were examined using the resistance change method. The MLG layer has a certain amount of resistance, which changes upon interaction with the NH_3 molecules. The principle of the sensing mechanism of the MLG-based gas sensor is based on a change in the electrical properties induced by charge transfer between NH_3 molecules.

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