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Highly selective and sensitive SnS_2 decorated rGO based chemoresistive gas sensors

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Abstract:
The growth of Internet of Things (IoT) have opened new opportunities for chemoresistive gas sensors. Two-dimensional (2D) materials including graphene-based materials and transition metal dichalcogenides materials are receiving significant attention as gas sensing materials due to their high surface area, numerous abundant sites, and excellent mechanical flexibility. Herein, we demonstrate chemoresistive gas sensors with excellent selectivity and ultrahigh sensitivity based on SnS_2 decorated rGO.

Key words: Internet of Things, two-dimensional materials, chemoresistive gas sensor, reduced graphene oxide, tin sulfide

Introduction

Since the advent of the Internet of Things (IoT), the necessity of sensors embedded in an object and connected through a network have increased dramatically [1]. The amount and concentration of specified gases in the environment are converted into electrical signals by gas sensors and the sensors are contributed to IoT by providing surround environment. Semiconducting materials based chemoresistive gas sensors with low cost and small size are one of the most promising candidates for the IoT [2-5]. Nitrogen dioxide (NO_2) gas is one of the most toxic gases to human health and the cause of air pollutant produced during combustion of fossil fuel, industrial factories and power plants. NO_2 is widely known for its adverse effects on the human body even at low ppm that health and safety guidelines suggest that even 3ppm or less NO_2 gas influences our health including olfactory paralysis. Therefore, the development of new sensors to detect NO_2 in the environment are important for improving the quality of environment and avoiding deterioration in our health and quality of life.

Nowadays, Graphene has attracted as a highly important material for application in field of gas sensors because of its high surface-to-volume ratios. Reduced graphene oxide (rGO), one of graphene derivatives, can be fabricated in large quantities with simple process. In addition, the numerous defect sites on the surface of rGO can react with specific gases and can easily controlled.

Herein, we report chemoresistive gas sensors with excellent selectivity and ultrahigh sensitivity based on SnS_2 decorated rGO. The sensing properties of the sensors are significantly enhanced compared to pristine rGO which provides a new and simple strategy to applicate NO_2 sensor for use in IoT.

Experimental

Gas sensing properties of SnS_2 decorated rGO based sensors were measured in a quartz tube by monitoring the variation of sensor resistance on flowing dry air to a calibrated NO_2 gas (balanced with dry air). The response of the sensors were accurately determined by measuring the base resistance after exposure to NO_2 gas. The sensor resistance was measured at a DC bias voltage of 0.5 V using a source measurement unit (Keithley 236). A constant flow rate of 500 sccm was flowed for dry air and NO_2 gas. The response of the sensors were precisely determined by the ratio of the fully saturated resistance after exposure to the NO_2 gas to the base resistance in dry air.

Result and discussion

We have successfully synthesized SnS_2 decorated rGO. The SnS_2 decorated rGO were drop casted on IDE for the sensing measurements. The device was exposed to 500 sccm of NO_2 gas balanced with dry air. The response of the sample was 16.5% calculated

by the following equation: $(R_{gas} - R_{air})/R_{air} \times 100$ where R_{air} and R_{gas} denote the resistance in the dry air and NO_2 gas ambient, respectively.

The response of the sensors to 5 ppm NO_2, 5ppm NH_3, 50 ppm CH_3COCH_3, 50 ppm C_2H_5OH are 16, 7, 0.01 and 0.6% respectively. The sensor showed the highest response to NO_2. These results suggest that the SnS_2 decorated rGO is suitable for the selective NO_2 detection.

Conclusion

We have investigated gas sensor based on SnS_2 decorated rGO. The sensors demonstrated high selectivity and sensitivity to NO_2 gas. We expect that the excellent properties demonstrated in this work will show the possibility of SnS_2 decorated rGO sensors in IoT.

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