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Efficient reducing method of graphene oxide for gas sensor applications

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Abstract

This research reports efficient reducing method of graphene oxide for gas sensor application. Graphene has been known to response gas such as nitrogen oxide (NO_2) or ammonia (NH_3) and change resistivity corresponding to the gas concentration. Here we carried out reduction of graphene oxide by hydriodic acid (HI) method [1], NH_2NH_2 [2] and thermal annealing [3] under H_2 atmosphere and compared gas sensing behavior of each reduced graphene oxide. We found that the reduced graphene oxide by HI method responded to nitrogen oxide gas strongly (sensitivity 5%) compared to that by NH_2NH_2 (sensitivity 2%) or thermal annealing under H_2 (sensitivity 0.15%).

Keywords: Graphene oxide ; gas sensor ; reduction method

1. Introduction

There is growing interests on graphene application such as transparent electrode, composite materials, sensors, etc. Recently, several researchers reported the possibility of application of reduced graphene oxide as gas sensor. Here we want to investigate the efficiency of our reducing method of graphene oxide using HI for gas sensor application that has been devised as low temperature reduction method of graphene oxide by our group.

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2. Experimental

Graphene oxide was prepared from graphite powder using the modified Hummers method. [4] (Hummers and Offeman 1958) A dilute GO suspension was spin-coated on inter-digitated electrodes (IDT) fabricated on Si wafer. The fabricated GOs on IDT were reduced using hydriodic acid vapor with acetic acid (HI method) at 4^{o}C [1], hydrazine at 80^{o}C [2] and thermal annealing under H_2 [3], separately. (Fig. 1)

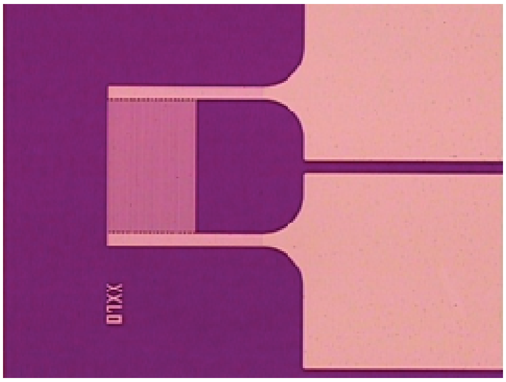

Fig. 1. Reduced graphene oxide on inter-digitated electrode (IDT) on Si

Those reduced graphene oxide (RGO) was investigated in terms of NO_2 gas sensing efficiency. To measure gas sensing behavior, we monitored change of the sensor resistivity depending on NO_2 gas concentration that was controlled by mass flow controller (MFC). (Fig. 2) Air was used as base-gas and 50 ppm NO_2 gas was mixed with base gas to make NO2 concentration from 8 to 22 ppm.

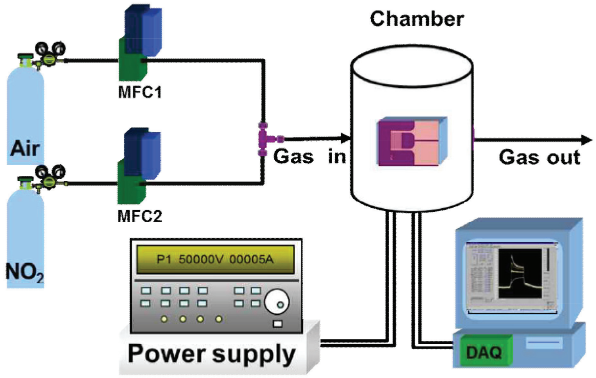

Fig. 2. Gas sensing measurement setup

3. Results and discussion

Gas sensitivity (S) was defined as follow: S (%)= |Ra-Rg|/Ra x 100, where Ra and Rg are resistance of the sensor in air and analyte gas. As shown in Fig. 3 and 4, the RGO using HI/acetic acid, NH_2NH_2 and thermal method under H_2 showed 5%, 2% and 0.15% of sensitivity at NO_2 8.2 ppm, separately.

Considering the sensitivity to NO2 gas, the reduction method of GO using HI/acetic acid was most efficient method.

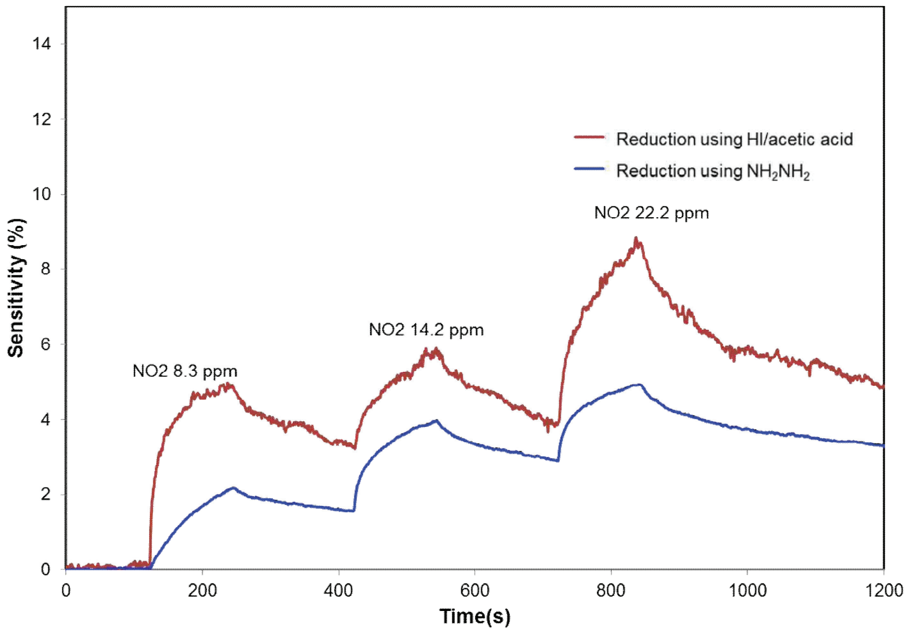

Fig. 3. NO_2 sensing of RGO obtained from HI/acetic acid and NH_2NH_2 reduction method

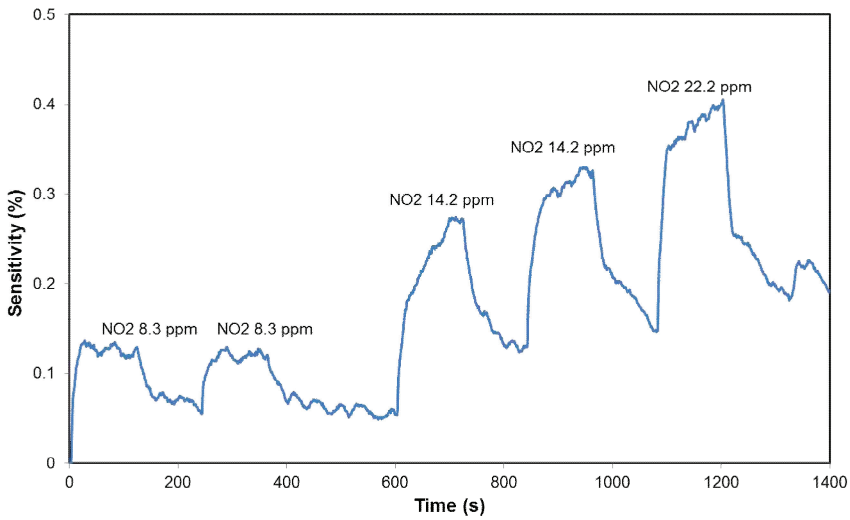

Fig. 4. NO_2 sensing of RGO obtained from thermal annealing under H_2

Here, we think that the efficiency of HI reduction method of GO for NO_2 gas sensor comes from doping effect originated from HI. According to the reference, conductivity or resistivity change of RGO upon NO2 gas sensing is determined by hole. [5] Therefore iodine is thought as efficient hole dopant compared to hydrazine or amine because of its strong electron accepting property. In this line, further investigation of electronic property of RGO depending on reduction methods is in progress. Development of gas sensor composed of RGO working at low temperature compared to other gas sensor such as metal oxide semiconductor type [6] or solid electrochemical gas sensor could be very interesting and important in terms of low power consumption applications.

Acknowledgements

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