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Low temperature gas sensing properties of Graphene Oxide/SnO_2 nanowires composite for H_2

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Abstract

In this work Graphene Oxide (GO) and SnO_2 nanowires (NWs) composite sensing performance were studied. Single crystal SnO_2 NWs were directly grown by thermal evaporation method and GO was successfully synthesized using modified Hummers method. RF magnetron sputtered Pt particles were used as a catalyst for the growth of SnO_2 NWs. Drop cast technique was used to deposited GO on top of the SnO_2 NWs. FE-SEM (LEO 1525) was used to investigate the morphology of SnO_2 NWs and GO. Fabricated sensors were tested towards various concentration of H_2 at different working temperatures. This GO/SnO_2 hybrid sensors show a reversible response to H_2 at low operating temperature.

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1. Introduction

Hydrogen is a well-known energy source that has the potentiality to reduce the problem of global energy demand. Unfortunately, H_2 is colorless and flavorless gas and can easily explode in air at concentration of only 4% and above [1]. It is important to detect H_2 at low temperature, enabling its use in a wide range of industrial

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applications.

Metal-oxide semiconductor (MOX) nanostructured, such as SnO_2, are the most interesting materials widely used for detection of gases, due to their high sensitivity, high stability and simple interface electronics [2]. However, their main disadvantage is the power consumption needed to reach high working temperature. GO have been considered as gas sensing material because of its high surface to volume ratio, and due to the functional groups present in the basal plane and edges that decrease the conduction and increase the sensitivity to gases. However, as widely known, GO is a high resistive material and it is important to reduce or combine with metal oxides to be used as chemical gas sensors [3].

In this work, nanowires of SnO_2 are combined with GO to form a heterojunction, for the detection of low concentration of H_2 at low temperatures.

2. Experimental

Alumina (99.9% purity, 2 mm x 2 mm,Kyocera, Japan) substrates were used to synthesize SnO_2 nanowires. Alumina substrates were ultrasonically cleaned for 15 minutes in acetone and dried with synthetic air. A thin layer of Pt catalyst was deposited on the alumina substrates by RF magnetron sputtering (75W argon plasma $5.5x10^{-3}$ mbar, room temperate).

2.1. SnO_2 nanowires growth by VLS technique

SnO_2 powder was placed into a tubular furnace and heated to a temperature of 1370 $^{\circ}C$ to promote evaporation of the powder. Moreover Pt- coated alumina substrates were placed into a tubular furnace for growth of SnO_2 nanowires. A pressure of 100 mbar was kept and argon gas flow of 100 SCCM was injected in the furnace to form vapors and to transport the vapors towards the alumina substrates in order to promote the growth of the nanowires.

2.2. Device fabrication and Graphene Oxide deposited on SnO_2 by drop cast method.

Platinum contacts and heater were deposited on the alumina substrates by DC magnetron sputtering. The prepared device was mounted on TO packages using electro-soldered gold wires.

GO was synthetized form natural graphite using modified Hummers method. Aqueous dispersions of GO at different concentrations were prepared to be deposited on top of SnO_2 NWs. GO powder was dissolved in pure water and stirred in 300rpm for 15 minutes in order to make homogeneous dispersion. Afterwards GO suspension was ultrasonicated for 15 minutes to reduce the size of GO flakes. GO solution (0.05 mg ml^{-1}) of 5 µl was dropped on a gold wire mounted device and dried in room temperature.

2.3. Gas sensing

The devices were mounted in the test chamber to investigate the electrical response of the sensors toward hydrogen gas in different working temperatures an at several concentrations.

Table 1. Working condition of gas sensing.

Chamber temperature	20 ^0C
Voltage applied for sensors	1V
Gas Flow	200 sccm
Working temperature	20-150 ^0C
Hydrogen concentration	20,50,100 ppm

3. Results

The morphology of SnO_2 and GO/SnO_2 NWs was investigated by FE-SEM. SEM measurement show that the