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BINARY NANOCOMPOSITES WITH OXIDIZED NANO-ONIONS AND REDUCED GRAPHENE OXIDE FOR SURFACE ACOUSTIC WAVE SENSOR

Bogdan Catalin Serban[1], Octavian Buiu[1], Marius Bumbac[2], Cristina Mihaela Nicolescu[3], Mihai Brezeanu[4]

[1]IMT Bucharest, National Institute for Research and Development in Microtechnologies, 126A Erou Iancu Nicolae, 077190 Voluntari, Romania.
[2]Valahia University of Targoviste, Faculty of Sciences and Arts, Valahia University of Targoviste, 13 Sinaia Alley, 130004 Targoviste, Romania, marius.bumbac@valahia.ro
[3]Valahia University of Targoviste, Institute of Multidisciplinary Research for Science and Technology, 13 Sinaia Alley, 130004 Targoviste, Romania
[4]National University of Science and Technology POLITEHNICA Bucharest, Faculty of Electronics, Telecommunications and IT, 1-3 Iuliu Maniu Blvd., district 6, 061071, Bucharest, Romania

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Introduction

Nitrogen dioxide, a reddish-brown gas with a strong, suffocating odor, is one of the most toxic air pollutants. This gas is a major cause of morbidity and mortality worldwide, even at low concentrations, if there is repetitive or long-term exposure.
Long-term exposure to a low concentration can destroy lung tissue leading to pulmonary emphysema. The people most affected by exposure to this pollutant are children. Combustion of fossil fuels, diesel engines, forest fires, and industrial activities are the most important sources of nitrogen dioxide pollution. Considering the high degree of toxicity, the market of nitrogen dioxide sensors has experienced substantial development in recent years.
Along with optical, electrochemical, resistive sensors, gravimetric sensors have been successfully used in the detection and monitoring of nitrogen dioxide concentration.
The sensitive films described in the study are used in the design of a surface acoustic wave (SAW) sensor. A surface acoustic wave device is usually composed of a piezoelectric substrate, a pair of interdigital transducers, as well as a layer sensitive to the analyzed gas. The electrical signal, applied to one of the transducers, generates a surface acoustic wave that propagates to the other transducer, the mechanical wave being converted into an electrical signal. The invention refers to sensitive layers made of new binary nanocomposites oxidized onion-type nanocarbon materials (oxCNOs) / oxide of reduced graphene (rGO).
The sensor used is a "delay line sensor" type, dual, made on a quartz piezoelectric substrate. The sensor presents a dual delay line to compensate for the thermal drift.

Materials and methods

The sensitive layers made of rGO / ox CNOs are deposited on the piezoelectric quartz substrate by the drop casting method or by the spin coating method.

The quartz substrate is cleaned for 10 minutes in the ultrasonic bath using sequentially equal volumes of acetone, ethanol, and finally deionized water;

CNOs are synthesized from nanodiamonds, by thermal treatment at 1650 ºC, in a helium atmosphere; Synthesis of ox CNOs (hydrophilic) nanocarbon materials is carried out by reacting with 3M nitric acid, at reflux, for 48 h.

The mixture is prepared by dispersing 2 mL graphene oxide in water - 1mg/mL that is subjected to ultrasound for two hours. The resulting dispersion is mixed with 10 mg of oxidized onion-type nanocarbon materials. The mixture is stirred for 3 hours, at room temperature on a magnetic stirrer.

The obtained solution is deposited by the drop-casting method on the quartz substrate (Figure 1). The sensitive layer obtained, deposited on the substrate, is dried in an oven, at 50 ºC, in vacuum, for 60 minutes.

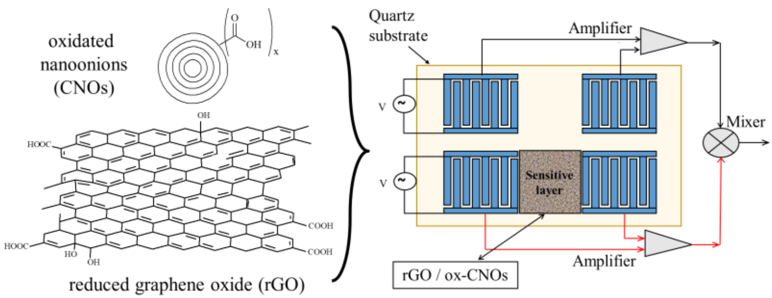

Figure 1. NO_2 SAW sensing device

Results and conclusions

Both onion-type oxidized nanocarbon materials and reduced graphene oxide are p-type semiconductors. 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 the nanocarbon material and thus, leading to a decrease in resistance.

The use of onion-type oxidized nanocarbon materials (ox-CNOs) / reduced graphene oxide (rGO) binary nanocomposite matrices confers several notable advantages, such as:

− both oxidized onion-type nanocarbon materials 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 them ("electric loading");

− π-π type interactions between reduced graphene oxide and oxidized onion-type nanocarbon materials ensure mutual homogeneous distribution in the sensitive layer.