CARBON NANOMATERIALS BASED CHEMIRESISTIVE GAS SENSORS

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[ENGINEERING OF BIOMATERIALS 163 (2021) 75]

Introduction

Due to their remarkable properties (electrical, thermal, mechanical, barrier) [1], carbon nanostructures become the subject of much contemporary research in material science, electronics, medicine and environmental protection. One of the enormous interests related to carbon nanostructures (especially graphene) is gas sensor development. The flexibility of using graphene and its derivates in various gas sensor architectures (chemiresistor, FET, electrochemical sensors) [2], large specific surface area, good electrical conductivity, easy synthesis, susceptibility to functionalization makes them a rising star of the gas sensor technology.

Nowadays, there is a lot of reports related to varieties of gases detectable by carbon nanostructure-based gas sensors. These materials can respond to low concertation of gases like VOC (volatile organic compounds), toxic gases [3] or traces of biological molecules [4]. One of the potential application in medicine is using carbon nanomaterial-based gas chemiresistor as a quick diagnostic tool similar to a breathalyser. The base concept is to detect low concentrations of metabolic products in human breath connected with human organism disorders like: presence of acetone related to diabetes (ketosis) [5] or the presence of ammonia accompanying chronic kidney disease [6]. Therefore, we would like to present the preliminary research about the possibility of using carbon nanostructured-based chemiresistor to detect ppm level concentrations of acetone.

Materials and Methods

Graphene oxide (GO) was prepared by the modified Hummers method [7]. GO was reduced by ascorbic acid (AA) on the ultrasonic bath at 60ºC for 60 minutes to partially reduced graphene oxide (pRGO). The effectiveness of the reduction process was evaluated based on XRD and EDS spectra. Next, carbon nanostructures prepared in this way were drop-coated onto interdigitated electrodes (Micrux ED-IDE1 Au).

Moreover, such interdigitated electrodes were overcoated by a thin (≈200 nm) diamond layer deposited in a microwave plasma-enhanced chemical vapor deposition system and terminated by hydrogen plasma.

Both gas sensors response measurement was carried out at room temperature and RH ~ 40%. The carrier gas was nitrogen, and the analyte was acetone. The measurement was performed for three different concentrations in a continuous experiment.

Results and Discussion

Spectroscopic techniques confirmed chemical changes that occurred in GO during oxidation and reduction processes. XRD diffraction spectra (FIG. 1) showed the presence of peaks typical for GO and pRGO.

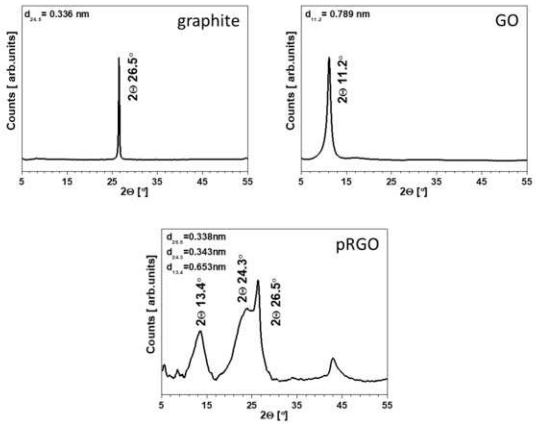

FIG. 1. Graphite, GO and pRGO XRD spectra.

EDX (TABLE 1) elemental analysis also confirmed partial reduction of GO with ascorbic acid. After the reduction process there was observed almost 50% reduction of oxygen atoms in carbon nanomaterial.

TABLE 1. EDX percent atomic composition of GO and pRGO.

Element	GO	pRGO
C [%]	77.40	90.72
O[%]	22.60	9.28

Preliminary gas sensor measurements showed promising results because the carbon nanostructure chemiresistors were able to detect acetone at ppm level in room conditions. The sensor response was stable during 5 h exposition of the material to the analyte, with slight sensitivity toward concentration changes.

Conclusions

To conclude, development of direct carbon nanomaterials functionalization towards response to specific gas/vapours is the tune of the future for gas sensors applications. This type of materials gives the promise to easily fabricated devices, working stable without the need of regeneration in opposite to commercial sensors, for instance metal oxides based. It reveals great potential in many fields like diagnostics or environmental monitoring, which are key factors in medical prophylaxis and fast diagnostics of human body dysfunctions.

Acknowledgments

P. S. Wrobel thank the National Science Centre of Poland for the financial support within the frame of the Preludium Program (grant agreement 2018/29/N/ST8/02356). O. Szabo and Š. Potocký acknowledge the GAV of the Czech Republic's Mobility project no. PAN-20-21. P. S. Wrobel, A. Kordyka and S. Pusz acknowledge the mobility project between the PAS and CAS (PAS-CAS project "Study of carbon-based sensors for detection of various gaseous media")

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