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Chemiresistive devices based on graphene decorated with metal oxide nanoparticles for NO₂ detection

Graphene is seen as a promising material for gas detection at room temperature, as to open the door to a new generation of low cost and low energy consumption sensors. However, a number of limitations have been identified when applying graphene to gas sensing, like low selectivity, slow response and long recovery times [1]. The present work is aimed at decorating graphene with metal oxide nanoparticles (MO-NP) to overcome these drawbacks. In particular, it has been found that the addition of MO-NP to graphene is able to modulate the selectivity of the material, and they improve the overall detection performance [2].

We present the sensing performance of chemiresistors based on graphene functionalized with MO-NP upon exposure to nitrogen oxide (NO₂). Four types of sensitive materials were investigated: pristine graphene (G), SnO₂-NP doped graphene (GSnO₂), ZnO-NP doped graphene (GZnO), and TiO₂-NP doped graphene (GTiO₂). The preparation of MO-NP doped graphene was performed by first freeze drying of graphene suspension previously prepared by a method described elsewhere [3]. The obtained graphene powders were mixed with MO-NP (3:1 mol/mol) and finally microwave irradiated for 5 minutes at 1000 W. The materials were characterized by SEM, TEM [Figure 1] and Raman spectroscopy.

Dispersions of these powders in ethanol and isopropyl alcohol/water were deposited by drop casting onto two types of substrates: alumina substrates for room temperature measurements and silicon microhotplates for measurements up to 300 °C.

The sensors were characterized in an automated gas line. As results of this investigation, an improvement in the response, especially in case of ZnO- and TiO₂-NP doping, was obtained; the latter device showing a remarkable sensitivity gain. Therefore, an improvement in sensor performance is demonstrated in terms of sensitivity and response time [

Figure 2].

References

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- [2] Chatterjee S.G., Chatterjee S., Ray A.K., A.K. Chakraborty A.K, *Sensors and Actuators B Chem.*, 221 (2015), 1170-1181

Figures

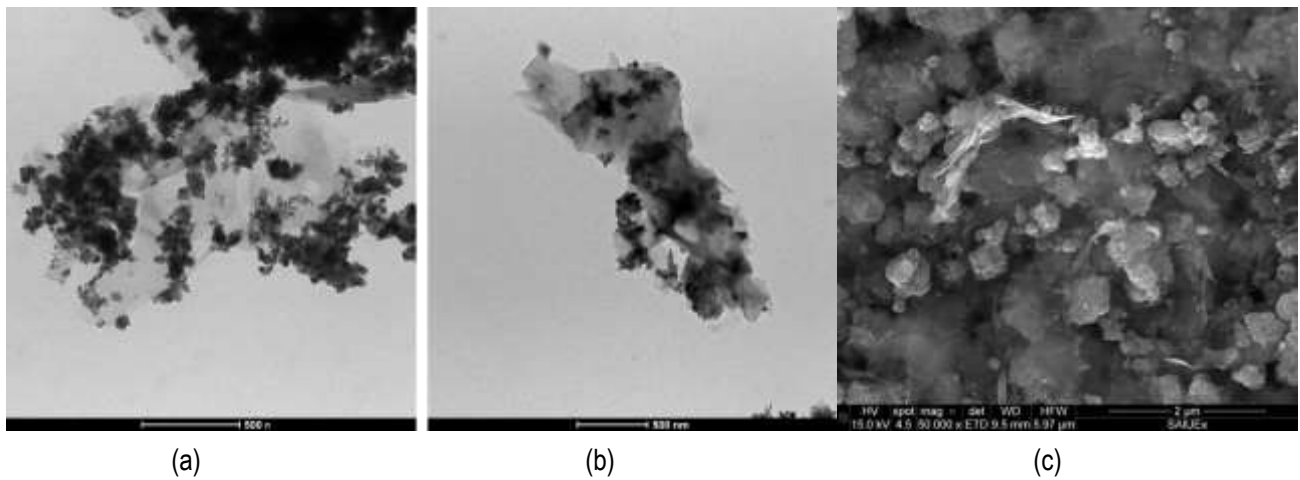


Figure 1: TEM images of (a) GSnO₂ and (b) GZnO; (c) SEM image of GTiO₂.

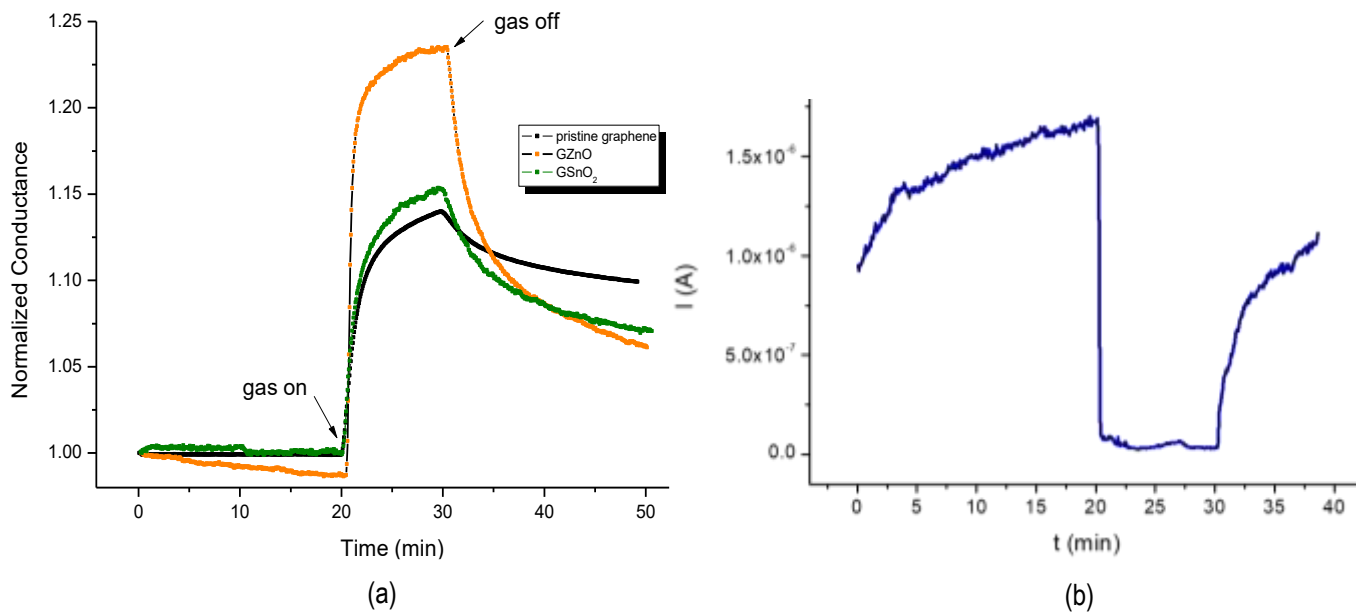


Figure 2 (a) Dynamic response of pristine graphene, GZnO and GSnO₂ sensors to 1 ppm NO₂ at room temperature; (b) dynamic response of GTiO₂ sensor to 1 ppm NO₂ at room temperature.

Acknowledgements

This research work has received funding from the Program Interreg V-B Sudoe of the European Union under grant agreement n°SOE2/P1/E0569 (NanoSen-AQM).