Graphene Nanocomposites for Online Monitoring of Individual Gases at Moderate Temperature

Thomas Hirsch[1], Alexander Zöpfl[1], Günther Ruhl[2], Frank-Michael Matysik[1]

[1]Institute of Analytical Chemistry, University of Regensburg, Universitätsstrasse 31, 93053 Regensburg, Germany
[2]Infineon Technologies AG, 93049 Regensburg, Germany
thomas.hirsch@chemie.uni-regensburg.de

Abstract

Simple and reliable monitoring of gas concentration is important in everyday-life. Graphene based sensors could provide a cheap and versatile alternative to well established metal oxide chemiresistors which need to be operated at high temperature. The large surface-to-volume ratio is one of the outstanding properties of graphene as sensor material, due to the absence of any bulk phase. Fast response time, high sensitivity and reversibility are accompanied with this property. Any kind of interaction between graphene sheets and adsorbates, influencing the electronic structure of graphene, leads to an altered charge carrier concentration or respectively electrical conductance of the material, already at ambient temperature and conditions.

Here, we report on reduced graphene oxide as a sensitive material for gas detection.[1] It is obtained by oxidation of graphite with subsequent reduction and can be dispersed in water, enabling an easy transfer. Application via spin coating to pre-structured microelectrodes comprising an interdigital structure was optimized and resulted in consistent layers of reproducible quality. These sensors not only responded to various analyte gases and concentrations, but the signal was also influenced by parameters like air humidity and temperature, but there is also a lack on selectivity. To overcome this drawback, functional groups, metal oxide and metal nanoparticles were introduced in one pot synthesis, in order to form nanocomposite materials. Additional decoration of reduced graphene oxide already deposited on the sensor with metal nanoparticles was achieved by electrochemical deposition. Upon different functionalizations, it was possible to achieve altered sensor behavior for different ambient gases like NO_2, N_2, O_2, CH_4, CO and H_2. Especially upon adsorption of NO_2 the high signal changes allowed a limit of detection in the sub-ppm range. The signal pattern for each gas allowed an individual recognition. Using multivariate analysis based on principal component analysis it was possible to discriminate each individual gas. This approach could be extended to build up sensor arrays like an artificial nose, in order to detect individual gases in a complex gas mixture at ambient conditions.

References

[1] A. Zöpfl, M.-M. Lemberger, M. König, G. Ruhl, F.-M. Matysik, T. Hirsch, T. Faraday Discuss. **173** (2014), 403