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Chemical gas sensors based on calixarene-coated discontinuous gold films

D. Filenko[a,b,*], T. Gotszalk[b], Z. Kazantseva[a], O. Rabinovych[b], I. Koshets[a], Yu. Shirshov[a], V. Kalchenko[c], I.W. Rangelow[b]

[a] *Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, 45, Prospekt Nauki, 03028 Kiev, Ukraine*
[b] *Institute of Microstructure Technologies and Analytics (IMA), University of Kassel, 40, Heinrich-Plett-Strasse, D-34132 Kassel, Germany*
[c] *Institute of Organic Chemistry, National Academy of Sciences of Ukraine, 5, Murmanskaya Str., 02094 Kiev, Ukraine*

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Abstract

We have designed, manufactured and measured performance of novel chemical gas sensors, which are based on conductivity modulation of discontinuous gold films on a dielectric substrate. The sensor elements were functionalized with different calixarenes. Several volatile analytes were exposed and dynamical sensor responses were investigated. Physical principles of the sensor operation are discussed. Our results show applicability of the proposed approach for chemical sensing and recognition.

Keywords: Discontinuous gold film; Calixarene; Chemical gas sensor

1. Introduction

Extensive researches in chemical sensor area involve the search and investigation of novel sensing techniques, approaches and materials. The promising organic materials for sensor applications are calixarenes because of their nano-size structure, excellent sorption abilities and selectivity, long time stability, technological feasibility. Calixarenes have cup-shaped spatial architecture, as it is shown in Fig. 1. Name “calix” originated from Greek word “bowl” or “cup”, whereas “arene” denotes benzene rings, which total number is represented in square brackets, e.g. calix[6]arene. Different complexing groups at the upper rim of calixarenes are able to attract desirable molecules with pre-defined selectivity. The lower rim functional groups of calixarenes are usually responsible for physical properties of calixarene molecules. Guest molecule can be also captured and released by the apolar cup-shaped cavity. This phenomenon determines zeolite-like behavior of calixarenes at the nano-scale, including excellent desorption ability.

Up to date, sensor applications of calixarene layers have been proposed for a few transducer types, e.g. quartz crystal microbalances (QCM) [1] and ISFETs [2]. In order to enhance the number of calixarene applications, we offer another transducing principle, which is based on conductivity modulation of discontinuous gold films (DGFs) on a dielectric substrate.

Electrical conduction of DGFs, which consist of a great number of separated gold nanoparticles (Fig. 2a), has been described by a number of scientists, e.g. [3,4]. This conduction can be explained in terms of percolation, activated tunneling and variable-range hopping theories. Fig. 2(b) illustrates tunneling connections between the nanoparticles along the percolation path. We show that modulation of the conduction current through DGF can be successfully implemented in high-sensitive, selective, miniaturized and low-cost chemical gas sensors for identification of volatile analytes in gaseous mixtures. This can be achieved by covering array of the DGF-based sensors with thin layers of different materials with specific sorption sensitivities. Molecular adsorption onto these

* Corresponding author. Tel.: +49 561 8044248; fax: +49 561 8044136.
E-mail addresses: filenko@isp.kiev.ua, filenko@schottky.physik.uni-kassel.de (D. Filenko).

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