DOI: http://doi.org/10.21698/simi.2022.ab27

ENHANCEMENT OF A ZNO/PANI SCREEN-PRINTED CARBON ELECTRODE WITH GOLD NANOPARTICLES FOR CARBON MONOXIDE SENSING

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Keywords*: carbon monoxide poisoning, gold nanoparticle activation, screen-printed carbon electrode; ZnO nanotube and PANI*

Introduction

Carbon monoxide (CO) poisoning can lead to major health threats and even death, thus a CO electrochemical sensor is developed by using ZnO nanotubes, Polyaniline (PANi), and gold nanoparticles (AuNPs). The porous morphology of ZnO has a high surface area, high electron mobility, excellent electrical properties, and adsorption sites, which allows for an excellent gas sensor response. ZnO system with PANi shows more sensitivity to CO concentration even at room temperature since the crystallite size of the ZnO/PANi multilayer is smaller and it is more porous hence having a greater surface area. Adding AuNPs enhances the selectivity to CO owing to the catalytic properties of AuNPs.

Materials and methods

The deposition of electrical traces is carried out by sputtering with the Q150R ES Sputter Coater on the flat surface of a hard support through a polymer mask cut with a laser cutter. Screen-printed carbon electrodes (SPCE) prepared with dedicated carbon nanofiber inks (DRP-CNFSOL) were thus obtained as films with a thickness of approx. 0.15 mm of desired size and shape. Initially, very thin polymer fibers were obtained from polymethyl methacrylate (PMMA) by electrospinning. The polymeric nanofibers were coated with ZnO ceramic oxides by sputtering, respectively magnetic spraying with a radio frequency magnetron, the polymeric core being removed by heat treatment which implicitly led to the obtaining of ZnO ceramic nanotubes. A ZnO dispersion was drop-casted onto the working electrode. A solution of 0.1 M aniline (which is originally 99.5% obtained from Sigma Aldrich) is prepared in 0.5 M sulphuric acid, hydrochloric acid, and formic acid. Cyclic voltammetry was the technique selected for electropolymerization on the screen-printed carbon electrodes using PARSTAT 4000 Gal/Pot. at 90 mV/s, an effective scan rate for creating uniform polymer film structures after a complete deposition of 8 consecutive layers. Gold nanoparticles were then electrochemically deposited on polyaniline-modified electrodes to maintain the proton-doped state of polyaniline.

Results and conclusions

The thickness of the uniform deposited layer was determined with Veeco DEKTAK equipment with an average thickness of 17.85 nm. The scanning electron microscopy (SEM) and atomic force microscopy (AFM) analysis images of the sample are shown in Figure 1.

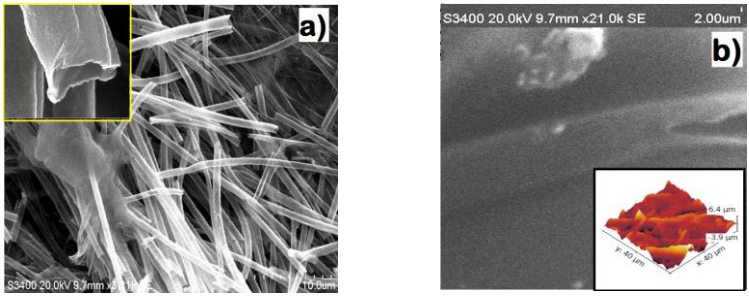

Fig.1. a) SEM image of ZnO nanotubes+PANi (inset pristine ZnO nanotubes) and b) SEM image ZnO nanotubes+PANi+AuNPs (inset 3D AFM)

The developed sensor was tested for sensitivity to CO using cyclic voltammetry (CV) as an electrochemical method. The measurements were made in two potential ranges -0.1 – 1.5 V and ± 1 V at two scan rates of 30 mV/s and 90 mV/s, respectively. The results obtained from exposure to the sensor at C1=13.64 %, C2=50.76 %, C3=72 %, and C4=89.99% CO testing show that the graph obtained at the scan rate of 90 mV/s with the potential -0.1-1.5 V shows the best quasi-linearity.

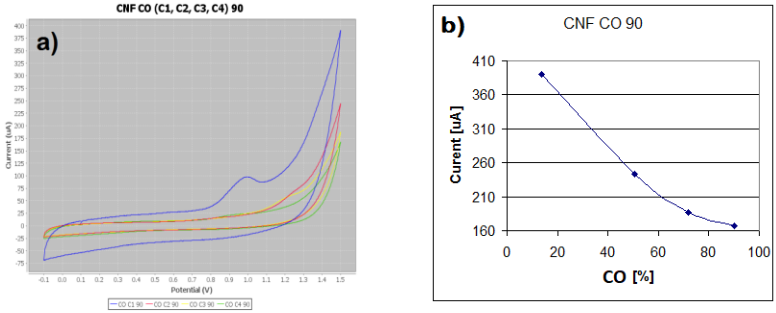

Fig.2. CV plot for sensor testing against carbon monoxide and b) oxidation peaks diagram

Acknowledgment. The work was supported by: grant P_37_766, code Mysmis 103847, no.68/08.09.2016, of the Romanian National Authority for Scientific Research and Innovation, NANO-IMUNELCHIMPLAT, Project/Competitiveness Operational Programme 2014-2020.