Optimization of Spray-Coated MWCNTs Based Working Microelectrodes for Electrochemical sensors

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Abstract

Easy, fast and reliable detection of species in environment under field conditions or in vitro/vivo online biodetection is one of the most discussed problems in these days. In general, small handheld, usually electrochemical, systems using miniaturized sensors are therefore developed [1, 2]. The main problem of electrochemical sensors miniaturization is reduction of their geometrical size in comparison to standard electrodes resulting in lower current response. This problem could be solved by creation of some 3D structures on the geometrically reduced electrode which could increase the active size of the electrode several times. Such electrode system could be used as a base for high sensitive intelligent sensors and biosensors [3].

Carbon nanotubes (CNTs) have been under scientific investigation more than fifteen years. Their unique properties predestine them for numerous potential applications including the working electrodes of electrochemical sensors [4-6]. Moreover the suspension made of CNTs with suitable vehicle can form the porous working electrode of high electrochemically active surface.

In this work the standalone multiwalled carbon nanotubes (MWCNTs) based spray-coated working electrodes of electrochemical sensors were optimized with respect to the accurate electrochemical behavior of deposited layers. Two types of thick-film platinum electrode contacts were investigated (Figure 1 left) and the suitable thickness of spray-deposited MWCNTs/DMF active layers was studied. Fabricated electrodes (Figure 1 right) were characterized optically using scanning electron microscopy and electrochemically in a standard redox couple of potassium ferro/ferricyanide employing cyclic voltammetry and impedance spectroscopy. The reversibility of the electrode system, influence of spray-coated layer thickness and platinum electrode contact size on the current response were investigated.

From the SEM images of fabricated Pt(+) contact/Al_2O_3 substrate crossing shown in figure 2 (left and middle) is clear that 1 ml of spray-coated suspension leave visible step between contact and the substrate, which almost disappear with 5 ml of spray-coated suspension. Other images of active layer taken on Pt contact and pure alumina substrate (Figure 2 right) confirmed worse coverage of alumina substrate by electrode material. This fact leaded to loosing of active layer adhesion during the measurement and thus the destruction of the electrode. This problem was observed namely on small $Pt_{(mk)}$ contact.

The electrochemical cyclic voltammograms of electrodes with small $Pt_{(mk)}$ contact and large $Pt_{(+)}$ contact are shown in the figure 3. From the figure 3 is clear that large $Pt_{(+)}$ contact gives more stable and accurate response which is probably given by better adhesion of MWCNTs active layer to platinum and better current propagation from the CNTs to the electrical circuit. This fact was also confirmed by electrochemical impedance spectroscopy. Next experiments also confirmed, that more stable and repeatable behavior was achieved using the electrodes with bigger platinum contact and lower thickness of deposited active layers.

References

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Figures

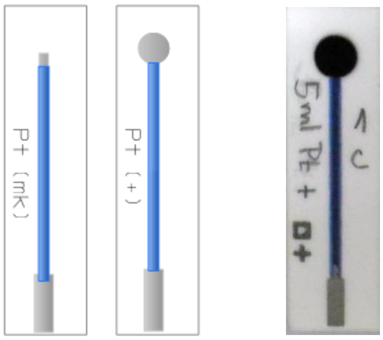

Figure 1. Two types of thick-film contacts design (left) and fabricated electrode (right)

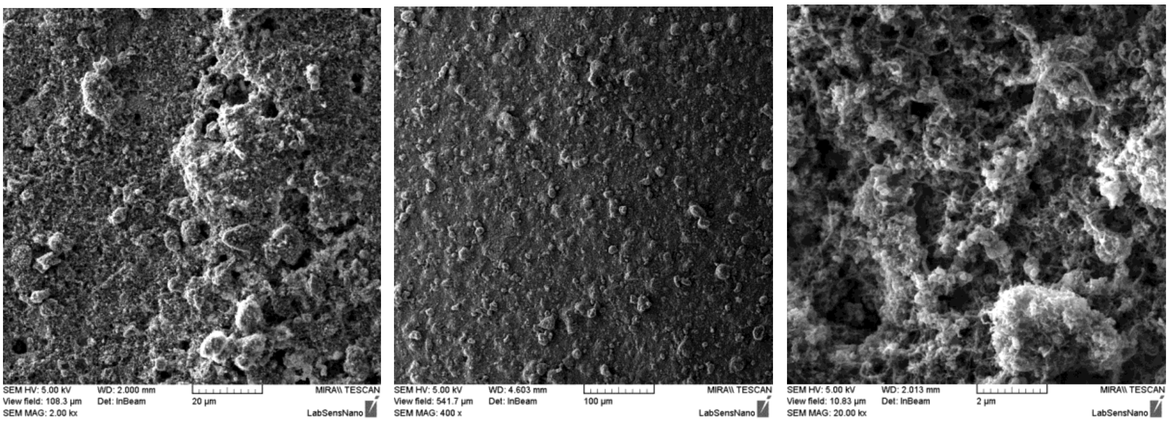

Figure 2. SEM microimages Pt(+) contact/Al_2O_3 substrate crossing covered with 1 ml of spray-coated MWCNTs/DMF active layer (left) and 5 ml (middle). The image of deposited active layer on the alumina substrate (right).

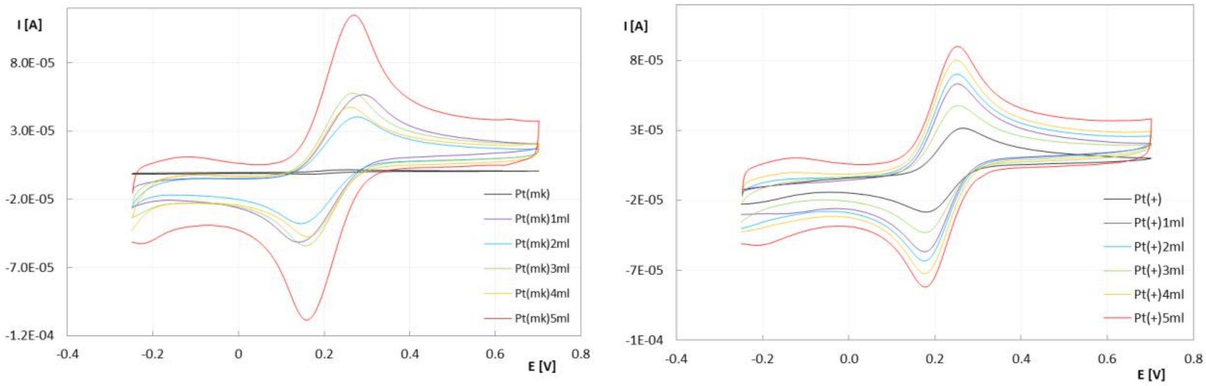

Figure 3. Cyclic voltammograms recorded at 50 mV/sec in 2.5 mM potassium ferro/ferricyanide solution for different active layer thickness achieved at small contact $Pt_{(mk)}$ (left) and large contact $Pt_{(+)}$ (right).

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