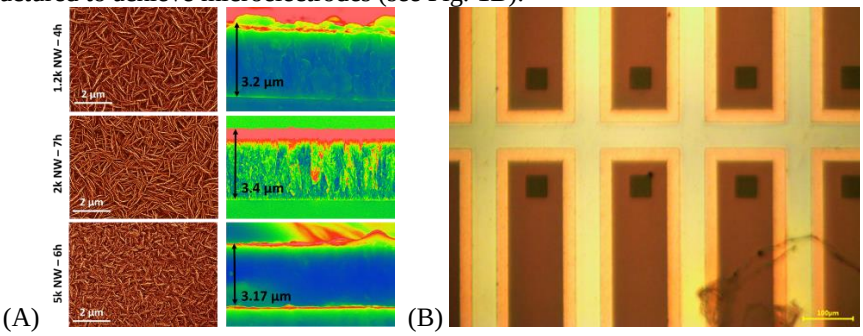
Functional conductive nanocarbons and diamond thin films for ultra-sensitive biosensing applications

Robert Bogdanowicz [a]

[a] *Department of Metrology and Optoelectronics, Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, 11/12 G. Narutowicza St., 80-233 Gdansk, Poland.*
e-mail: rbogdan@eti.pg.edu.pl (e-mail address of the corresponding author)

Abstract:
The most common material for electrodes in electrochemical sensing systems is gold or other noble metals, as these can be applied though physical vapor deposition. Nevertheless, they are optically opaque or highly absorptive, thus cannot be used as the optically functional working electrode. Among the most interesting novel, optically transparent candidate materials for electrochemical analyses are (i) boron-doped diamond (BDD), (ii) high surface area carbon nanowalls (B:CNW) and (iii) fluorine-doped tin oxide or tin-doped indium oxide.
The novel B:CNW and BDD biosensing surfaces are grown by the microwave plasma-assisted CVD. The effect of boron incorporation not only enhances the electrical or electrochemical properties but also influences the structure of CNW by changing it from the maze-like to a heterogeneous distribution of nearly straight walls [1] (see Fig. 1A). B:CNW or BDD could be nanostructured to achieve microelectrodes (see Fig. 1B).



(A) (B)

Figure 1. SEM of top and cross-section of B:CNW surfaces (A) and fabricated microelectrodes (black squares - 30 µm) by photolithography and SiO_2 masking process (B).

Both BDD and B:CNW electrochemical electrodes are characterized by outstanding electrochemical properties such as high standard rate constant (k°), low peak-to-peak separation value (ΔE) for the oxidation and reduction processes of the $[Fe(CN)_6]^{3-/4-}$ redox system, and low surface resistivity. For these reasons, B:CNW were successfully applied for primary nucleic acid bases detection [1] or paracetamol determination [2], while BDD electrodes have been used for the development of a rapid-response ultrasensitive biosensor for influenza virus detection [3] and for stress marker - Isatin determination [4].
Taking into consideration achieved properties, the studied electrodes could be applied in the point-of care (PoC) diagnostic systems, which are currently one of the fastest growing areas of health care. Diamond based sensors are still not utilized in POCs, while they exhibit much higher sensitivity with price at the same or lower level. Regarding to wider functionality and price of developed diamond sensor technology it must be noted that such a device will be able to effectively compete with the above-cited products on the demanding markets.

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