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RESEARCH PAPER

Transparent microelectrode array in diamond technology

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Abstract We report on the development of a diamond-on-sapphire microelectrode quadrupole array, substituting the commonly used inert metal electrode material by nano-crystalline diamond (NCD). This allows to combine the transparency (desired for fluorescence analysis) with the properties of an inert quasi-metallically doped diamond electrode. The NCD film was nucleated by BEN (Bias Enhanced Nucleation) on double side polished sapphire substrates and outgrown by hot filament CVD. Early quadrupole results on isolated adrenal chromaffin cells show the detection of amperometric signals corresponding to the quantal release of catecholamines contained in a single nanometric secretory vesicle.

Keywords MEA · Nanodiamond · Cell secretion analysis

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1 Introduction

Planar microelectrode arrays are commonly used to detect amperometric and voltammetric signals in electroanalysis and biomedical sensing like in the in-vivo characterization of cell membrane channel activities. They are mostly based on a patterned array of inert metal electrodes (like Au or Pt) deposited onto Si, glass or plastic substrates. Metal electrodes allow the analysis of redox activities within the water dissociation window (~1.5 V), not easily allowing the detection of organic molecules with higher oxidation potential (like phenols). In the case of Boron Doped Diamond (BDD), water dissociation is suppressed across a wider potential window (~3 V), where the detection of substances like dopamine, histamine and even phenols has already been reported [1]. In addition, metal electrodes are non-transparent and do not allow high resolution fluorescence imaging from the backside of the sample. Even the surrounding silicon on which they are located is only transparent in the IR range, while bio-glass may display a cut-off wavelength in the mid-UV, depending on its composition [2]. Diamond on the contrary, possessing a semiconductor bandgap of 5.47 eV, is transparent between 225 nm and 12 μm [3]. NCD has been deposited onto transparent substrates like sapphire, glass and even high temperature stable plastic [4–6]. However, up to now the properties of the deposited nanocrystalline films have not been discussed in conjunction with biochemical and electrochemical applications, which require high corrosion resistance. In addition, the diamond surface can be functionalized in many ways to tailor its electrochemical sensitivity or further improve its already high biocompatibility [1, 7]. An oxygen termination is mostly used, like in this investigation, resulting in a highly corrosion resistive surface.