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Cellular adhesion and neuronal excitability on functionalised diamond surfaces

P. Ariano[a,b,1], P. Baldelli[a,c,1], E. Carbone[a,c], A. Gilardino[a,b], A. Lo Giudice[a,d], D. Lovisolo[a,b], C. Manfredotti[a,d], M. Novara[a,c], H. Sternschulte[e], E. Vittone[a,d,*]

[a]*INFM (National Institute for Matter Physics), UdR Torino-University, Torino, Italy*
[b]*Department of Animal and Human Biology, "Nanostructured Interfaces and Surfaces" (NIS) Centre of Excellence, University of Torino, Torino, Italy*
[c]*Department of Neuroscience and NIS, University of Torino, Torino, Italy*
[d]*Experimental Physics Department and NIS, University of Torino, Torino, Italy*
[e]*Institut für Physik, Universität Augsburg, Germany*

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Abstract

The resting or evoked activity of neuronal networks can be effectively monitored by using multielectrode arrays (MEA), which allow non-invasive extracellular stimulation and recording of electrical signals in parallel from multiple cells. Diamond possesses unique properties (biocompatibility, optical transparency, possibility of modifying the electronic and hydrophilic/hydrophobic properties at the nanoscale), which makes it a promising material to fabricate stable MEAs for long-term extracellular recordings of electrical and optical signals in living neurons.

In order to explore the capability of diamond for fabricating MEAs as cell-based biosensors, we report here the first study on the adhesion and cell excitability (i.e., the ability of cells to generate and propagate trains of electrical impulses) on hydrogen (HTD)- and oxygen (OTD)-terminated diamond surfaces. Adhesion and functional properties of cultured rat hippocampal neurons and chick ciliary ganglia have been quantitatively evaluated using well-established biophysical techniques. Cells survive, adhere and maintain their electrical properties (synaptic activity, ion channels availability, Ca^{2+} signals during neuronal stimulation) for days provided that mixtures of adhesion molecules (poly-D-lysine, poly-DL-ornithine, laminin) are used to favour cell anchoring on diamond surface.

Keywords: Diamond film; Chemical vapour deposition; Biocompatibility; Biomaterials; Neurons

1. Introduction

Neuronal activity is responsible for much of the complex behaviour of organisms. Voltage-gated ion channels are membrane proteins involved in maintaining the cellular membrane electrical potential and generating trains of electrical impulses (action potentials). Their modulation via pharmacological manipulation can be detected by changes in the firing pattern of these signals. Thus, the use of cultured neurons as sensor elements provides the opportunity for studying in vitro brain activity and for undertaking high-sensitivity pharmaceutical screening.

Neuronal activity can be directly measured using extracellular microelectrodes, which provide a stable, non-invasive interface for monitoring the functioning of a neuronal network. Planar microelectrode arrays interfaced with cultured neurons generally consist of glass or silicon over which a conductor is deposited and patterned [1]. The cell/sensor interface is created as neurons adhere directly to the planar electrode structure. Alternatively, neurons can be directly coupled to the bare gate of a silicon field effect transistor to improve the signal/noise ratio [2]. However, the

* Corresponding author. Experimental Physics Department, University of Torino, Via P. Giuria 1-10125 Torino, Italy. Tel.: +39 011 6707317; fax: +39 011 6691104.
E-mail addresses: vittone@ph.unito.it, vittone@to.infn.it (E. Vittone).
[1] P. Ariano and P. Baldelli contributed equally to this work.

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