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Editorial

Novel Sensing Devices Open New Perspectives in Cellular Neuroscience

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Abbreviations

MEA: Multi Electrode Arrays; DBM: Diamond-Based MEA

Health problems related to chronic pain, hearing loss, paralysis, retinal degeneration, as well as neurological and neuropsychiatric disorders [1,2] need a more detailed knowledge at molecular and cellular levels to be fully understood. Electrical stimulation and recording of brain neurons activity is one approach widely used to investigate these phenomena.

Extracellular microelectrodes are employed in *in-vitro* systems for the stimulation and recording of neuronal networks activity, and thus be used as tools for understanding the synaptic changes under physiological conditions or at the early stages of developing neurodegenerative diseases.

Neural stimulation is usually obtained by delivering electrical pulses, inducing the incoming of biological events (action potentials and post-synaptic activity) that are acquired as voltage or current signals.

An ideal microelectrode should provide safe levels of stimulation and guarantee a large set of waveforms with tuneable frequency and record small (down to μV or pA) and fast signals (milliseconds) without introducing size and time distortion. Moreover, the chemical inertness is essential in order to avoid the induction of any chemical reactions on the electrode or in the tissue, as well as its biocompatibility.

Single neurons addressing and minimal tissue damage induction requires an effective miniaturization of these electrodes.

Among the many biocompatible (gold, platinum, iridium, titanium) and non-reactive materials (stainless steel, iridium oxide, silicon), many research groups explore the fabrication of Multi Electrode Arrays (MEAs) with diamond because of its excellent biocompatibility, unique mechanical properties, wide optical transparency window and the possibility of surface chemical functionalization [3,4]. This interest was also driven by the development of new techniques for micro/nano modification of diamond [5-10]. Diamond-based MEAs (DBMs) can now cover a large variety of different kind of measurements due to the fabrication geometry:

- Low-density DBMs can resolve the electrical activity or neurosecretion events in complex neuronal networks [11],
- High-density DBMs can provide a subcellular electrochemical map of exocytosis [12]
- Ultralow-density DBMs can assay the protein content of the physiological liquids that condition the growth, formation and maturation of complex neuronal networks [13].

Improvements are already needed in order to offer easy to use and standardized sensors or to implement integrated acquisition system that guarantee the possibility of simultaneous recording of release of neurotransmitters (pre/post synaptic activity), action potential waveforms (AP firing) and fluorescence imaging, thus providing multi-task sensing devices. This last acquisition approach is highly desirable for real-time monitoring of neuronal functionality, as the combined measurement provide a complete picture of the functional or pathological state of the neuronal network. Indeed, defects or alterations of vesicle fusion and neurotransmitter release at the *presynaptic terminals* and signals acquisition at the post-synaptic site, where AP firing are generated induce neurological and neuropsychiatric diseases [14-16].

Thus, new microelectrode arrays (MEAs) able to achieve selective stimulation and recording of central neuron excitability as well as precise monitoring of synaptic activity are highly desirable. This technological evolution will promote a new understanding of neuropathologies, formulation of advanced therapies and construction of novel neuroprosthetic devices.

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Conflict of Interest

The authors declare no conflict of interest.

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