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Quantal Release of Dopamine and Action Potential Firing Detected in Midbrain Neurons by Multifunctional Diamond-Based Microarrays

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Micro-Graphitic Single Crystal Diamond Multi Electrode Arrays (μG-SCD-MEAs) have so far been used as amperometric sensors to detect catecholamines from chromaffin cells and adrenal gland slices. Besides having time resolution and sensitivity that are comparable with carbon fiber electrodes, that represent the gold standard for amperometry, μG-SCD-MEAs also have the advantages of simultaneous multisite detection, high biocompatibility and implementation of amperometric/potentiometric protocols, aimed at monitoring exocytotic events and neuronal excitability. In order to adapt diamond technology to record neuronal activity, the μG-SCD-MEAs in this work have been interfaced with cultured midbrain neurons to detect electrical activity as well as quantal release of dopamine (DA). μG-SCD-MEAs are based on graphitic sensing electrodes that are embedded into the diamond matrix and are fabricated using MeV ion beam lithography. Two geometries have been adopted, with 4 × 4 and 8 × 8 microelectrodes (20 μm × 3.5 μm exposed area, 200 μm spacing). In the amperometric configuration, the 4 × 4 μG-SCD-MEAs resolved quantal exocytosis from midbrain dopaminergic neurons. KCl-stimulated DA release occurred as amperometric spikes of 15 pA amplitude and 0.5 ms half-width, at a mean frequency of 0.4 Hz. When used as potentiometric multiarrays, the 8 × 8 μG-SCD-MEAs detected the spontaneous firing activity of midbrain neurons. Extracellularly recorded action potentials (APs) had mean amplitude of ∼−50 μV and occurred at a mean firing frequency of 0.7 Hz in 67% of neurons, while the remaining fired at 6.8 Hz. Comparable findings were observed using conventional MEAs (0.9 and 6.4 Hz, respectively). To test the reliability of potentiometric recordings with μG-SCD-MEAs, the D_2-autoreceptor modulation of firing was investigated by applying levodopa (L-DOPA, 20 μM), and comparing μG-SCD-MEAs, conventional MEAs and current-clamp recordings. In all cases, L-DOPA reduced