Boron-Doped Diamond Neurosensors and Neural Stimulating Electrodes

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Carbon fiber based electrodes (CFBE) are widely employed to monitor dynamics of neurochemical events in the extracellular space within the brain[1]. However, fast scanning rates (>100 V/s) are necessary for sensing, and a corresponding high baseline current exists, making detection of basal neurotransmitter levels difficult. Artificial stimulation of neurotransmitter release is normally required. Yet, prolonged stimulation can damage tissue through electrolysis and evolution of gas. CFBEs are also plagued by fouling, preventing long-term stability for chronic use. Further advances in understanding neurotransmission at a cellular level could result from design of superior electrode materials.

Diamond electrodes possess exceptional electrochemical properties, including low baseline current and a wide potential window of water stability[2]. They demonstrate, by far, the most stable response of any carbon-based electrode, also without requiring extensive pretreatment to regenerate the electroactive surface. Diamond surfaces are not completely inert; their surface termination can be modified and influences the electrochemical properties. We present our progress in the development of boron-doped diamond film microelectrodes for *in vitro* detection of dopamine and adenosine. The role of electrode surface chemistry on neurotransmitter detection is also investigated.

Diamond microelectrodes, **Fig. 1A**, were fabricated by hot-filament chemical vapor deposition. Tungsten wires were sealed into quartz capillaries for the substrates **(Fig. 1B)**. Selective diamond growth at the tungsten tip (25 μm diameter or less) was achieved. The growth conditions were optimized to maintain the mechanical stability of the quartz insulation (**Fig. 1C**).

Through diazonium salt electrochemistry, functional groups (Phenyl-SO_3, -NO_2,-NH_2,-H, and –CF_3) were covalently bound to diamond. Phenyl-SO_3 modified diamond (**Fig. 2**) displays sharper peaks and smaller ΔE_p compared to the unmodified electrode surface, suggesting faster kinetics and greater extent of reversibility.

Dopamine adsorption, considered necessary preceding electrochemical detection, decreases temporal resolution. Preliminary results using CFBEs, **Fig.3**, indicate that adenosine pre-adsorption might prevent the further adsorption of dopamine, while still permitting detection. Results from *in vitro* detection of dopamine and adenosine will be presented. Dopaminergic neurons B65 and B20 in the buccal ganglia of *Aplysia californica* will be chosen for this purpose. We will explore the use of diamond microelectrodes for stimulating and sensing both chemical and electrical activities in single neurons.

[1] Wightman RM *et al, Current Opinion in Chemical Biology* **6** (2002) 696-703.
[2] Martin HB *et al*, *J. Electrochem. Soc.* **143** (1996) L133-L136.

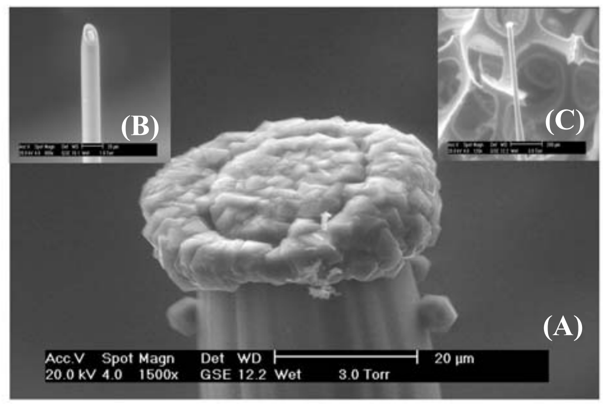

Fig. 1: *Scanning electron images of diamond film microelectrode: (A) Diamond selective growth at the tip; (B) tungsten wire substrate sealed in quartz; (C) intact electrode body.*

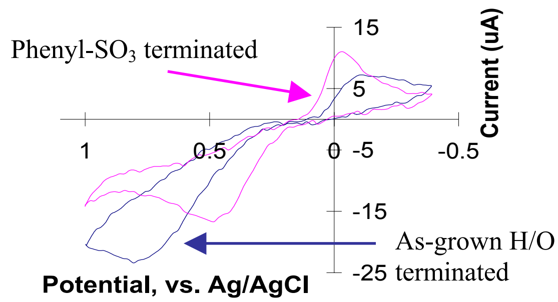

Fig.2: *Cyclic voltammograms of dopamine in as-grown diamond and electrochemically modified Phenyl-SO_3 terminated diamond macroelectrodes.*

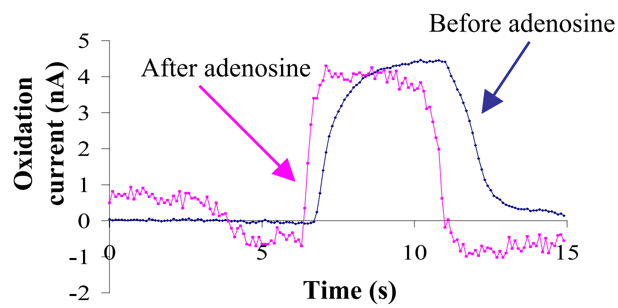

Fig.3: *Cyclic voltammograms of dopamine before and after adenosine detection, using CFBEs as sensor.*