395d Nanocrystalline Diamond Neurosensors

Heidi B. Martin, Songtao Xie, and Jeffrey M. Halpern

Carbon-fiber based electrodes (CFBE) are widely employed to electrochemically monitor dynamics of neurochemical events in the extracellular space within the brain; the needle-like electrodes minimize tissue damage and permit detection at the time scale (millisecond) of neurotransmission. 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. 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 are currently developing implantable, diamond-based, nanocrystalline microelectrodes to study neurotransmission. The diamond electrodes mimic the needle-like geometry of carbon-fiber electrodes. They are fabricated by selective CVD deposition of a nanocrystalline, diamond thin film onto a tungsten wire substrate, which is pre-sealed into quartz. We will present our progress in understanding the unusually high sensitivity of these electrodes for neurochemical detection, as related to our unique diamond growth method. In addition, further miniaturization of these electrodes, and understanding the role of electrode surface chemistry on neurotransmitter detection is investigated. Lastly, results from in vitro detection of serotonin and adenosine will be presented.