Fabrication and characterization of all-diamond boron doped microelectrodes for electrochemical measurement with fast-scan cyclic voltammetry

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Diamond is a versatile material with high biocompatibility, chemical inertness and when doped, can be made to become a semiconductor. When highly doped with boron, the diamond material can be utilized as an electrode for electrochemical measurement, with a wide working potential window in aqueous solutions. Boron-doped diamond microelectrodes have been previously grown on sharpened tungsten and platinum wires, and thus require a secondary insulation such as glass, epoxy or parylene-C. Here we report on the further development and optimization of an alternative, freestanding, boron-doped diamond electrode to feature an all diamond microelectrode, where a solid, boron doped diamond core is insulated using micro-polycrystalline diamond. The polycrystalline diamond shell improves on the biocompatibility, and flexibility of traditionally hand fabricated microelectrodes. These boron-doped microelectrodes (BDDME) are rectangular in structure, with a cleaved planar tip, or a laser cut planar tip utilized for electrochemical sensing. Using these electrodes, we studied how a cleaved BDDME surface compared with a laser cut BDDME surface and looked at surface enhancements and cleaning methods. Additionally, we characterized these electrodes using scanning electron microscopy, cyclic voltammetry, electrical impedance spectroscopy, Raman spectroscopy and fast-scan cyclic voltammetry. We measured several common neurotransmitters for the linear dynamic range, detection limit and electrochemical noise including dopamine, serotonin, 3,4-Dihydroxyphenylacetic acid, ascorbic acid, and hydrogen peroxide using FSCV. Using the all diamond electrodes for neurotransmitter analysis is advantageous as it is the gateway to wafer batch fabrication of microelectrodes, decreasing errors generated in the traditional hand fabrication methods, and building towards a scalable batch method for electrode array technologies.

Key Words: Electrochemical sensor, Biosensors, Biocompatible material, Dopamine

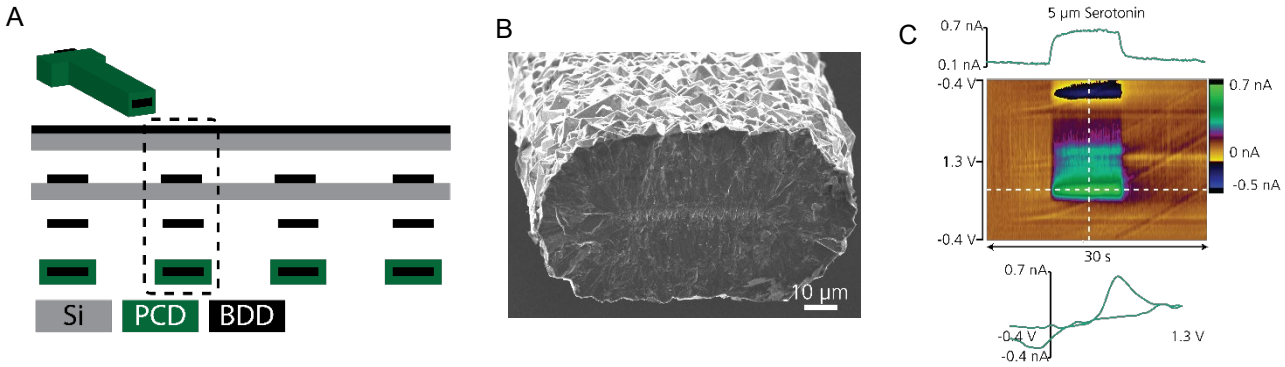

Fig 1.A. Representative fabrication scheme for the all diamond microelectrodes. B. Representative scanning electron micrograph of the all diamond microelectrode, showcasing the BDD core, and insulating PCD layer. C. Representative *in vitro* response of 5 µM serotonin when measured on the BDDME using fast-scan cyclic voltammetry.