Nanostructured diamond microelectrode arrays for neural recording and stimulation

Gaëlle Offranc Piret

Clinatec Laboratory, Biomedical Research Center Edmond J. Safra,
Minatec Campus, Grenoble, France

The development of stimulation implant and neuronal recording system currently needs highly stable and biocompatible microelectrode arrays (MEAs) offering large number of electrodes. However, high density integration requires small diameter electrodes leading to both a low signal to noise ratio (due to high impedance) and a small charge injection capacity. These issues could be overcome by nanostructuration of the electrode surface. In this context, 3-µm-long carbon nanotubes (CNTs) embedded into conductive boron-doped diamond (BDD/CNTs/BDD) has recently been proposed as a new 3D nanostructured BDD electrode material with very promising electrochemical properties [1]. Here, we integrated either conventional BDD or 3D nanostructured BDD fabrication steps in MEAs and tested these devices for neural recordings. These two types of MEAs were processed on glass substrates using micro-fabrication steps. Conventional BDD resulted in a macro-structured surface, while 3D nanostructured BDD displayed a high-aspect ratio nanostructured surface and a very large surface area. CV measurements show that 3D nanostructured BDD microelectrodes have an increased double layer capacitance compared to the conventional BDD ones, exhibit a large theoretical charge storage capacity (10 $mC.cm^{-2}$ for 20-µm diameter electrodes), and have a much lower noise level compared to the conventional BDD ones, which is consistent with their much lower impedance. These 3D nanostructured BDD microelectrodes allowed for low amplitude signal recording and for stimulation of in vitro cultured hippocampal cells and whole acute embryonic mouse hindbrain spinal cord preparations [2]. In conclusion, 3D nanostructured BDD is a promising new material for neural interfacing and the development of neural prosthesis or implants for rehabilitation.

REFERENCES

[1] C. Hébert, J-P. Mazellier, E. Scorsone, M. Mermoux, P. Bergonzo. Boosting electrochemical properties of nanocrystalline diamond electrode using a vertically-aligned carbon nanotube scaffold. Carbon, 2014, 71: 27–33.

[2] G.Piret, C.Hébert, JP.Mazellier, L.Rousseau, E.Scorsone, M.Cottance, G.Lissorgues, M.Heuschkel, S.Picaud, P.Bergonzo, B. Yvert. 3D-nanostructured boron-doped diamond for microelectrode array neural interfacing. Biomaterials, 2015, 53:173-183