Towards Maskless Production of Custom Neuronal Recording Graphene Microelectrode Arrays

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This work aims to demonstrate our advances in the fabrication process for high – performance Microelectrode Arrays (MEAs) that can be custom produced and may be used to explore in vitro neural networks.

Our microelectrodes are composed of graphene, a very promising material since it combines several interesting features such as low noise, excellent electrical conductivity, good charge injection capacity, biocompatibility and transparency[1].

Graphene was grown by Chemical Vapor Deposition (CVD) on copper foil and transferred to the substrate.

Experimental analysis of our graphene MEAs yield very good performance. Electrode characterization was performed through Cyclic Voltammetry (Figure 2) and Impedance Spectroscopy (Figure 3), with better results than those previously reported in the literature. Both techniques were used to evaluate the quality of the microelectrodes as they enable the determination if sensors are working properly and hence can stimulate and/ or register electrical signals from cell cultures. Impedance average at 1 kHz for our electrodes is 70 kΩ, which is compatible with commercial MEAs which exhibit values between 30 and 400 kΩ[2]. Biocompatibility tests were performed. After nine days in culture, there was adhesion of a large number of neurons and growth of glia on MEA surface. Therefore, our device is also biocompatible and adequate to measure cellular potentials.

We are developing a direct laser write fabrication process for arbitrary microelectrode position and connectivity. Aligned exposures with a Heidelberg DWL66FS system with 405 nm laser are used for the conductive region of MEAs, as well as modified SU – 8 with photoinitiator at 405nm exposures. Challenges in processing of graphene microelectrodes in direct write will be discussed.

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[1] B. Koerbitzer, P. Krauss, C. Nick, S. Yadav, J. J. Schneider, C. Thielemann, 3D Mater., vol. 3, n. 2, 24004 (2016).
[2] M. Systems, "Microelectrode Array (MEA) Manual", 131 (2017)

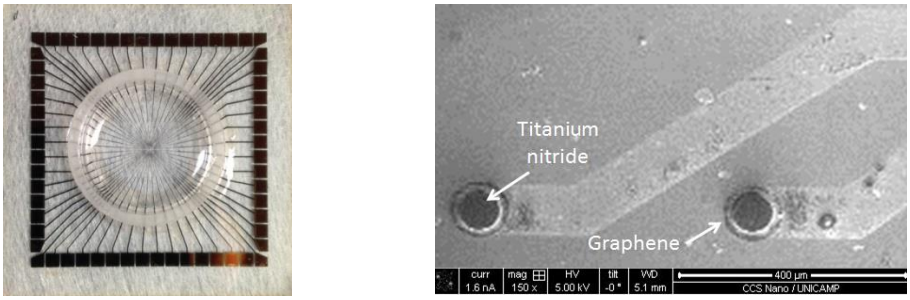

Figure 1: (a) Fabricated MEA and (b) image obtained from Scanning Electron Microscopy of two MEA microelectrodes. As can be seen, graphene cover the TiN microelectrode.

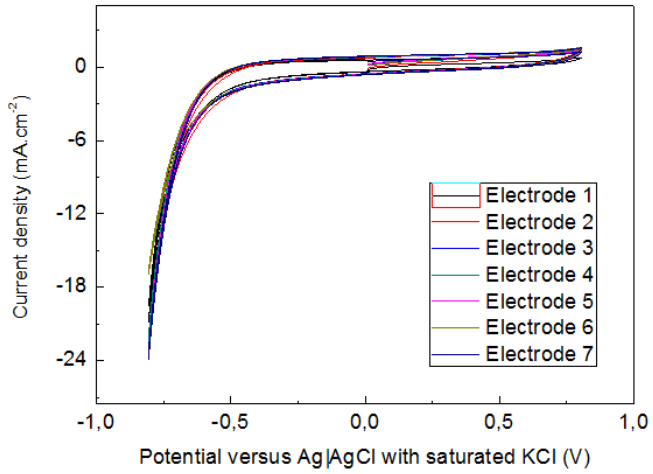

Figure 2: Cyclic Voltammetry test for seven microelectrodes from our fabricated MEA.

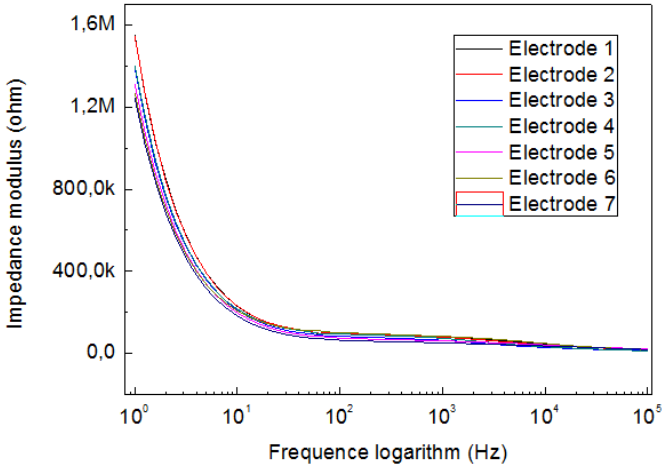

Figure 3: Results from Impedance Spectroscopy measures referring to a seven microelectrodes from our fabricated MEA.