NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2022-2023

Multifunctional and Multiscale Brain Interface

The human brain is made up of 100 billion neurons that interact with each other through 100,000 billion connections. While structural maps have reached single cell precision over whole brain, mapping all neuronal signals simultaneously is not achievable today, as those electrical signals are spatially wide spread. In particular, microscopic mechanisms and their interplays with larger scales remain hidden to the available technology, which impedes to assess all processing abilities of neurons. The aim of the internship is to perform ‘pilot’ experiment to combine microscale electrical sensing with arrays of graphene field effect transistors (GFETs) and functional Magnetic Resonance Imaging fMRI imaging. Signals recorded from neuroimaging data reveals the activity of large assembly of neurons, and are usually complex signals where different frequencies reveals different characteristics of the functioning of the brain. Currently, low frequency (<0.1Hz) are not achievable for fMRI nor EEG, but for G-FETs. This suitable devices for neural interfaces have demonstrated their ability to detect a wide range of neuronal signals, from slow waves to single spike and ion channels *in-vivo* and *in-vitro* [1-3]. The propose approach is a way to get low frequencies signals at the same time for fMRI and electrical signals and confront the mathematical models [4,5].

A first task will focus on the fabrication and characterization of GETs arrays dedicated for long lasting brain recording. Electrical properties of the devices will be followed at the frequencies of interest, and the impact of high magnetic field on the detection performances will be investigated. Then, pilots’ experiments will be done that combine electrical recordings and BOLD imaging on rodents. Lastly, an important part of the work will be devoted to analyses the recorded signals.

Involved laboratories: Institut Néel and Grenoble Institut of Neurosciences
Backgrounds in cleanroom nano and micro microfabrication, and electrical instrumentation will be an advantage for the smooth running of the internship.

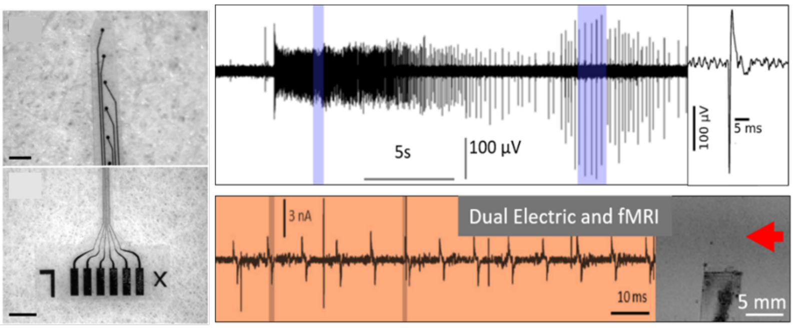

Figure: (top) time course of the extracellular potential recorded with intracortical flexible microelectrodes fabricated at Neel Institut (right). (Bottom) Spike-like potential impulses (ms) recorded during an fMRI imaging sequence, after subtraction of field gradient-induced artifacts. On the right, imprint of the flex-MEA on fMRI image. The flex-MEA is invisible.

1. Veliev, F. et al. 2D Mater. 5, 045020 (2018).
2. Veliev, F. et al. Front. Neurosci. 11, (2017).
3. Masvidal-Codina, E. et al. Nat. Mater. 18, 280–288 (2019).
4. Achard, S. et al. Phys. Rev. E 77, 036104 (2008).
5. Achard, S. & Gannaz, I. ArXiv181110224 Math Stat (2018).

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Contact: Cécile Delacour (Néel), Emmanuel Barbier (GIN)
e-mail: cecile.delacour@neel.cnrs.fr , Emmanuel.Barbier@univ-grenoble-alpes.fr