Graphene based correlative microscopy for multiphysics sensing within neuron networks

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Monitoring the electrical activity of neuron cells is a widespread and reliable method to understand the functions and organization of neuron networks (NNs). Nowadays, neurons are easily interfaced with bioelectronics such as microelectrode (ME) or field-effect transistor (FET) arrays. These tools have been designed to suit to very local (~1µm²), fast (~1ms) and accurate (~100µV) measurements. FETs can reach high sensitivity (~2-4 mS/V) while reducing their size which makes them good candidates to dive into neuron activity. The field-effect detection of neuron single spikes has been first revealed with silicon nanowire[1] and carbon nanotube-FETs that still provide the highest spatial resolution. Over the past decade, graphene FETs appeared as promising tools to investigate signal transmission within cell cultures[2][3]. Because of their high sensitivity, biocompatibility, chemical stability and strong coupling with cell, G-FETs have succeeded to detect a wide range of neuronal signals from single action potential[4][5] to ionic currents[6]. In addition, graphene optical transparency allows to combine the electrical recording with transmission imaging which provides the missing high spatial resolution to graphene electronics. Here, we present a multiphysics approach combining electrical sensing using G-FETs with fluorescence microscopy. This method allows to follow in real-time the electrical activity of NNs with other biophysical parameters (e.g. ion fluxes, temperature) revealed by using sensitive fluorescence biosensors. This versatile platform is suitable to follow complementary biophysical features and to probe metabolism of different type of cells.

References

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Figures

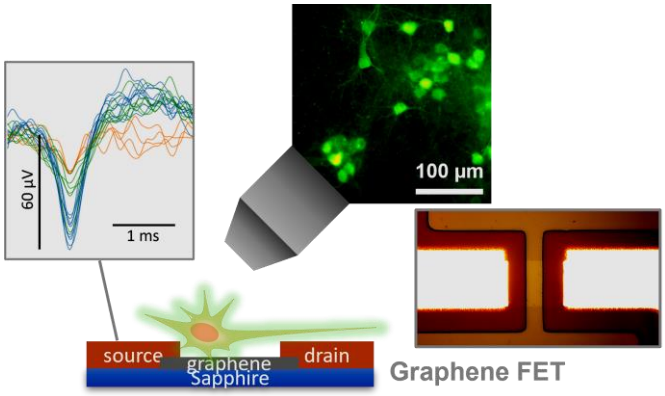

Figure: Coupling neuron spike detection (G-FET) with fluorescence microscopy (e.g. calcium imaging) allow to reach complementary information on neuron network activity and metabolism.