Graphene nanoelectronics meets neurofluidics for versatile labs on chip

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New methods and new technology are currently required to interrogate neuronal cells by many means and at multi-scale, in-vivo and within model neural networks in-vitro. In particular, to understand how neural circuits operate, we need access to activity of large numbers of neurons at the same time, and record their activity at the single cell level regarding the lot of information which relies at the level of synapses and ion channels. In that race, Graphene offers an ideal platform for recording and culturing neural networks, regarding its exceptional neuronal affinity and the presence of readily accessible surface charges which give the unprecedented possibility to realize a direct coupling with cells to detect ion fluxes at the nano[1,2] and mesoscale.[3,4] Here, we report on a novel and versatile approach that combines array of graphene field effect transistors (GFET) and microfluidic platforms for culturing and sensing neurons in designable network architecture.[5] The fluidic microchannels, somatic and synaptic chambers enable to define the neuron network topology, while the graphene devices provide localized, highly sensitive and optically transparent sensing sites. The efficient cell-sensor alignment obtained by the microfluidic circuit enables to reach the highest reported signal-to-noise ratio for single-units detection with GFETs, revealing additional information that remain hidden from recordings when using conventional microelectrode arrays (MEAs). Thus, the combination of graphene sensors and microfluidic circuits leverages the advantages of two state-of-the-art technologies for highly efficient sensing of model neural networks. Being fully transparent and therefore compatible with optogenetic tools and high-resolution microscopy, this novel platform could provide a versatile lab-on-chip for diagnosis and treatment of tomorrow, and open avenues of investigation for studying topological neuron network and living matter in general.

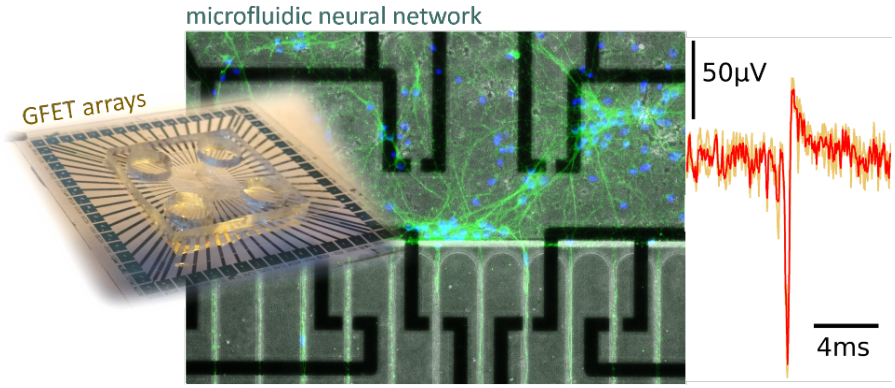

Figure 1: Neuron-gated GFET arrays with microfluidic circuits (left) allows for highly efficient extra-cellular detection of action potential (right). The graphene sensing site being optically transparent, cells can be observed in real-time during the culture (several weeks) providing multiple way to follow both structural and functional changes within model neural network (center).

References

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