Kirigami Graphene Transistors for Recording the Electrical Activity of Single Neurons

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Recent advances in the fields of optics, biochemistry, and nanotechnology have instigated a multidisciplinary effort to understand the neural circuitry of the human brain. The electrodes currently used for *in vivo* single neuron sensing have not significantly advanced over the past century. The industry standard remains simple insulated conductive shafts with small exposed tips. Graphene-based field-effect transistors are flexible yet strong, biocompatible, and able to locally amplify the electrogenic signals produced by neurons. This combination of material characteristics makes graphene ideal for next-generation biosensing applications.

The graphene in our experiments is etched into patterns inspired by the Japanese paper art of *kirigami* to enable in-plane stretching.[1] The devices are then stretched over cells, isolating the graphene from possible substrate noise while forming a conformal coating over the cell to obtain the optimal signal-to-noise ratio. The flexibility of these devices makes them promising as "wearable" electronics for cells with applications for both *in vivo* and brain slice electrophysiological experiments.

Here we present characterization and initial single cell measurements from these devices. First we investigated thermal noise limits,[2] and addressed concerns that the aqueous electrolyte environments would significantly lower carrier mobility.[3] In addition we present early results from electrical interaction with cardiomyocytes and immortalized mouse neuronal cells.

References

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[2] Crosser, M.S., Brown, M.A., McEuen, P.L., Minot, E.D., Nano Letters, 8 (2015) 5404-5407
[3] Brown, M.A, Crosser, M.S., Leyden, M.R., Qi, Y., Minot, E.D. APL, 9 (2016) 093104

Figures

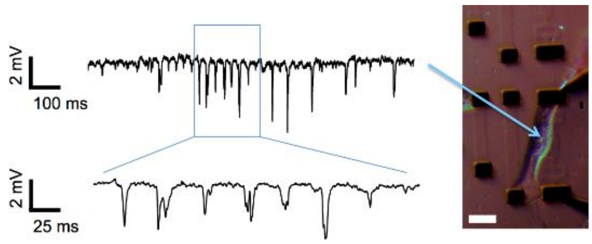

Figure 1: Rapid spikes recorded from an immortalized mouse neuron (KTAR1).

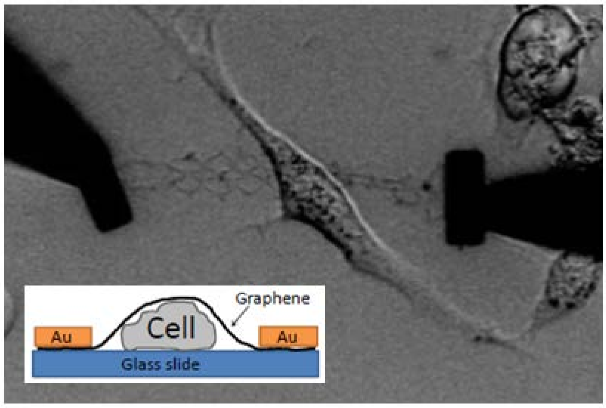

Figure 2: Kirigami patterned graphene stretched over a cardiomyocyte. Insert shows side-view schematic and material details.