Flexible Graphene Transistors for Bioelectronics

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Abstract

Tremendous efforts have been made in the last decades to develop an efficient interface between electronics and living cells. Solution-gated field-effect transistors (SGFETs) based on graphene are a promising technology for this application since they offer a high chemical stability, biocompatibility, low electronic noise as well as high transconductance and thus high sensitivity to electrical changes in the gate. We have already demonstrated that graphene SGFETs on rigid substrates can be used to detect signals from living cells [1, 2]. However, in order to perform in-vivo measurements it is a key requirement to integrate graphene SGFETs on flexible substrates in order to improve the mechanical and electrical contact between the tissue and the transistor and at the same time minimize tissue damage.

In this work we present the fabrication of graphene SGFETs on flexible polymer substrates using high quality CVD graphene. The transistor performance in electrolyte, including the intrinsic electronic noise, is investigated. We compare the performance of flexible and rigid SGFETs and show that the both type of devices exhibit similar transconductance and electronic noise. In addition, we show that the device performance is unaffected by bending the devices both in concave and convex shape. No device degradation is observed when repeated bending is performed.

After successful culture of electrogenic cells on the graphene devices, we demonstrate the successful recording of action potentials of these cells (see Figure 1) using arrays of graphene field-effect transistors. Finally, we will show results from in-vivo recordings using flexible graphene SGFETs in the visual cortex of rats. We demonstrate the electrical recording of brain activity with these transistors and compare their performance to state-of-the art platinum microelectrodes. Our work is an important milestone towards the goal of developing a new generation of neural prostheses based on flexible graphene electronic devices.

Figures

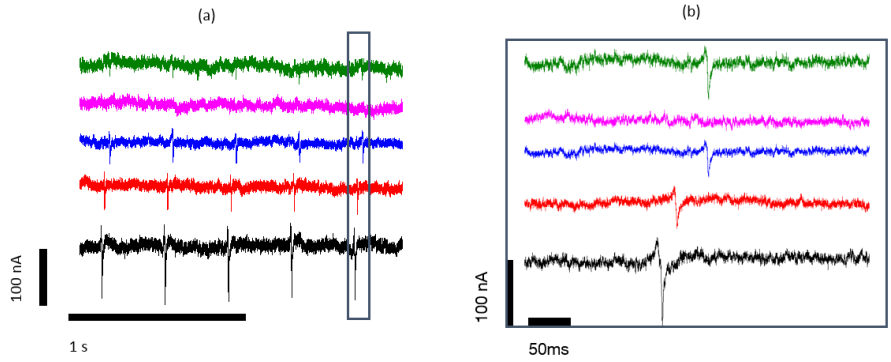

Figure 1: a) Recorded current of flexible graphene solution-gated field-effect transistors showing action potentials of HL-1 cells. b) Zoom into a).

References

[1] L. Hess et al., *Small* 11, 1703–1710 (2015)
[2] L. Hess et al., *Proceedings of the IEEE* 101, 1780 (2013)