Flexible graphene-based neural implants for depth brain recordings

Andrea Bonaccini Calia[a], E. Masvidal[b], Nathan Schaefer[a], M. Dasilva[c], E. Del Corro García[a], C. Hébert[a], X. Illa[b], R. Villa[b], Maria V. Sanchez-Vives[c], Rob Wykes[e], A. Guimerà[b], Jose A. Garrido[a,d]

[a] *Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and The Barcelona Institute of Science and Technology, Bellaterra, Spain*
[b] *Institut de Microelectrònica de Barcelona (CNM), Bellaterra, Spain*
[c] *Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS) Barcelona, Spain*
[d] *ICREA, Barcelona, Spain*
[e] *UCL Queen Square Institute of Neurology, Faculty of brain science, London*
andrea.bonaccini@icn2.cat

Neuroelectronic devices are powerful tools that enable us to better understand the human brain and therefore to explore the utilization of brain-computer interfaces for improving the lives of patients suffering from neural disorders or loss of motor/sensory functions. [1] Despite the current advances, important refinements are still needed to fulfil the demanding requirements of an ideal interface with the nervous tissue, such as low invasiveness, long term efficacy as well as large number of recording/stimulating sites.

Graphene and graphene-based materials are very promising candidates for neural interfacing. [2,3] They combine biocompatibility, chemical stability, low dimensionality and thus mechanical flexibility, extraordinary electronic properties and easy integration in micro-devices on flexible technology.

In this work, we show the integration of graphene solution-gated field-effect transistors (g-SGFETs) onto flexible polyimide substrates to obtain biocompatible intra-cortical neural probes. In order to penetrate the dura and be inserted into the brain tissue, the flexible neural probe was stiffened with a bio-resorbable silk-fibroin coating that dissolves after few minutes in contact with the brain tissue. We use the intra-cortical g-SGFETs neural probes to monitor the brain activity in a wide frequency range, from infraslow oscillations to local field potentials. This technology represents a novel tool that can be applied to the study of neurological diseases such as epilepsy, stroke and migraines. [2, 3]

References

[1] Gopala K. Anumanchipalli et al, Nature (2019) p. 493–498
[2] C. Hébert et al., Adv. Funct. Mater. (2017), [1703976]
[3] Masvidal et al., Nature Materials (2019) p 280–288

Figures

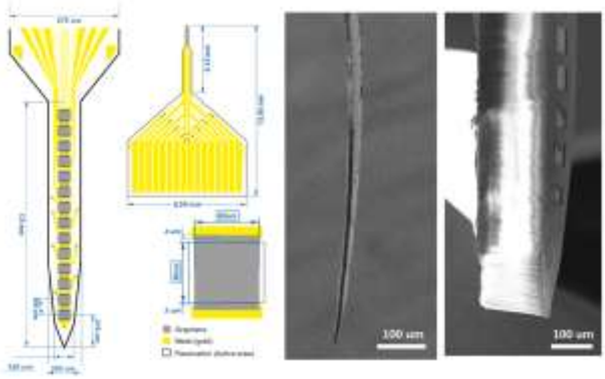

Figure 1: Graphene-based intra-cortical neural implants. SEM image of a flexible intra-cortical probe's tip without (left) and with (right) silk-fibroin coating.

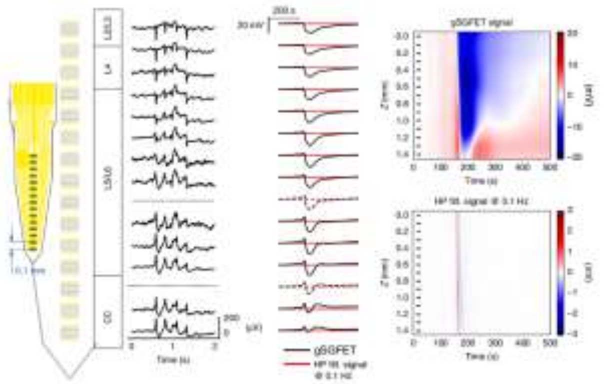

Figure 2: Neural recordings in a rat´s brain showing infra-slow brain activity as well as higher frequency oscillation typical of LFP. [3]