Towards long term stable high channel count flexible neural interfaces based on nanoporous graphene electrodes

Georgios Alexandros Katirtsidis[1]
Eduard Masvidal[1], Xavi Illa[2,3], Anton Guimerà-Brunet[2], Jose Antonio Garrido[1,4]
[1]*Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Campus UAB, Bellaterra, Spain.* [2]*Instituto de Microelectronica de Barcelona IMB-CNM (CSIC), Campus UAB, Bellaterra, Spain.* [3]*Centro de Investigacion Biomedica en Red de Bioingeneria, Biomateriales y Nanomedicina, Instituto de Salud Carlos III, Madrid, Spain.* [4]*ICREA, Barcelona, Spain.*
alexandros.katirtsidis@icn2.cat

Recently, great efforts have been made towards the development of flexible neural interfaces for recording and/or stimulation of neural activity with high spatial resolution, paving the way for in-depth study as well as innovative therapies for neurodegenerative diseases[1,2,3]. This work focuses on the fabrication and in-vitro characterization of flexible subcortical and epicortical neural interfaces capable of offering high spatial resolution for recording and stimulation brain activity, designed for future human translation. Utilizing a wafer-scale thin-film fabrication process and graphene-based nanoporous electrode material [1], we achieve bidirectional electrodes for recording and stimulation, exhibiting low impedance and high charge injection limits. The subcortical lead features 2 metal layers and 33 electrodes of two micrometer-scale sizes, spanning over a 5 mm long and 1.2 mm wide area and thus allowing for current stirring during stimulation. The epicortical lead features 71 electrodes of 3 different sizes. Additionally, we propose an organic(PI)/inorganic(Al_2O_3) method for enhancing the long-term stability of flexible graphene-based neural interfaces, tested on interdigitated electrodes and under accelerated aging conditions, with which we achieved stability for more than 1.5 years of equivalent time at 37°C so far.

References

[1] Viana D., Walston S.T., Masvidal-Codina E. et al, Nature Nanotechnology (2024)
[2] Lee K., Paulk A.C., Ro Y.G et al, Nature Communications,15 (2024) 218
[3] Ramezani M., Kim JH, Liu X. et al, Nature Nanotechnology (2024)

Figures

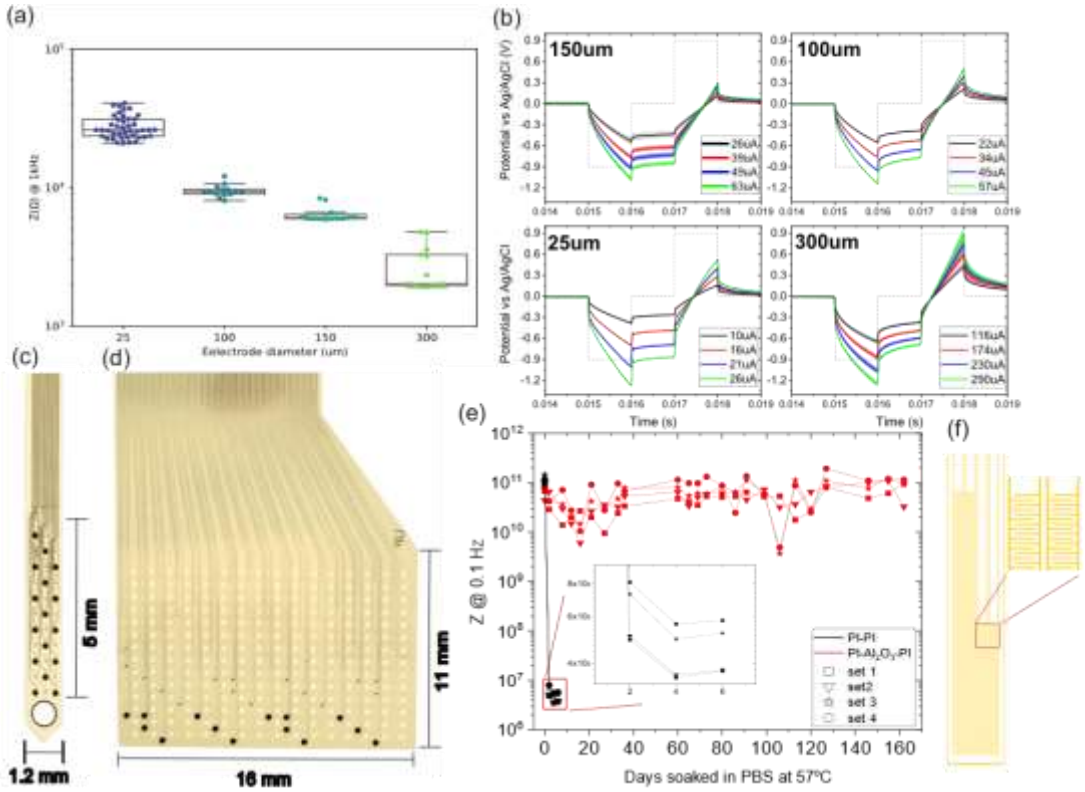

Figure 1: (a) Impedance at 1kHz for four sizes of electrodes, (b) voltage response to current pulses, (c) subcortical and (d) epicortical leads, (e) accelerated aging test comparing impedance (0.1Hz) of IDEs with two encapsulation strategies: PI-PI and PI-Al_2O_3-PI, (f) the IDEs device under test.

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