Innovative Graphene-based Implantable Technology Paves the Way for High-precision Therapeutic Applications

2024-01-13

A study published in Nature Nanotechnology presents an innovative graphene-based neurotechnology with the potential for a transformative impact in neuroscience and medical applications. This research, spearheaded by the Catalan Institute of Nanoscience and Nanotechnology (ICN2) together with the Universitat Autònoma de Barcelona (UAB) and other national and international partners, is currently being developed for therapeutic applications through the spin-off INBRAIN Neuroelectronics.

Following years of research under the European Graphene Flagship project, ICN2 spearheaded in collaboration with the University of Manchester the development of EGNITE (Engineered Graphene for Neural Interfaces), a novel class of flexible, high-resolution, high-precision graphene-based implantable neurotechnology. The results published in Nature Neurotechnology aim to contribute with innovative technologies to the blooming landscape of neuroelectronics and brain-computer interfaces.

EGNITE builds on the vast experience of its inventors in fabrication and medical translation of carbon nanomaterials. This innovative technology based on nanoporous graphene integrates fabrication processes standard in the semiconductor industry to assemble graphene microelectrodes of a mere 25 µm in diameter. The graphene microelectrodes exhibit low impedance and high charge injection, essential attributes for flexible and efficient neural interfaces.

Preclinical Validation of Functionality

Preclinical studies by various neuroscience and biomedical experts that partnered with ICN2, using different models for both the central and peripheral nervous system, demonstrated the capacity of EGNITE in recording high-fidelity neural signals with exceptional clarity and precision and, more importantly, afford highly targeted nerve modulation. The unique

combination of high-fidelity signal recording and precise nerve stimulation offered by EGNITE technology represents a potentially critical advancement in neuroelectronic therapeutics. This innovative approach addresses a critical gap in neurotechnology, which has seen little advancement in materials over the last two decades. The development of EGNITE electrodes has the capacity to place graphene at the forefront of neurotechnological materials.

International Collaboration and Scientific Leadership

The technology presented today builds on the legacy of the Graphene Flagship, a European initiative that during the last decade strived to advance European strategic leadership in technologies that rely on graphene and other 2D materials. Behind this scientific breakthrough is a collaborative effort led by ICN2 researchers Damià Viana (now at INBRAIN Neuroelectronics), Steven T. Walston (now at University of Southern California), and Eduard Masvidal-Codina, under the guidance of ICREA Jose A. Garrido, leader of the ICN2 Advanced Electronic Materials and Devices Group, and ICREA Kostas Kostarelos, leader of the ICN2 Nanomedicine Lab and the Faculty of Biology, Medicine & Health at the University of Manchester (UK). The research has had the participation of Xavier Navarro, Natàlia de la Oliva, Bruno Rodríguez-Meana and Jaume del Valle, from the Institute of Neurosciences and the Department of Cellular Biology, Physiology and Immunology of the Universitat Autònoma de Barcelona (UAB).

The collaboration includes the contribution from leading national and international institutions, such as the Institut de Microelectrònica de Barcelona - IMB-CNM (CSIC), the National Graphene Institute in Manchester (UK), and the Grenoble Institut des Neurosciences - Université Grenoble Alpes (France) and the University of Barcelona. The technology integration into the standard semiconductor fabrication processes has been performed at the Micro and Nanofabrication cleanroom of the IMB-CNM (CSIC), under the supervision of CIBER researcher Dr Xavi Illa.

Clinical Translation: Next Steps

The EGNITE technology described in the Nature Nanotechnology article has been patented and licensed to INBRAIN Neuroelectronics, a spin-off based in Barcelona from ICN2 and

ICREA, with support from IMB-CNM (CSIC). The company, also a partner in the Graphene Flagship project, is leading the translation of the technology into clinical applications and products. Under the direction of CEO Carolina Aguilar, INBRAIN Neuroelectronics is gearing up for the first-in-human clinical trials of this innovative graphene technology.

The industrial and innovation landscape on semiconductor engineering in Catalonia, where ambitious national strategies plan to build state-of-the-art facilities to produce semiconductor technologies based on emerging materials, offer an unprecedented opportunity to accelerate the translation of such results presented today into clinical applications.

Read the original article on Autonomous University of Barcelona (AUB).