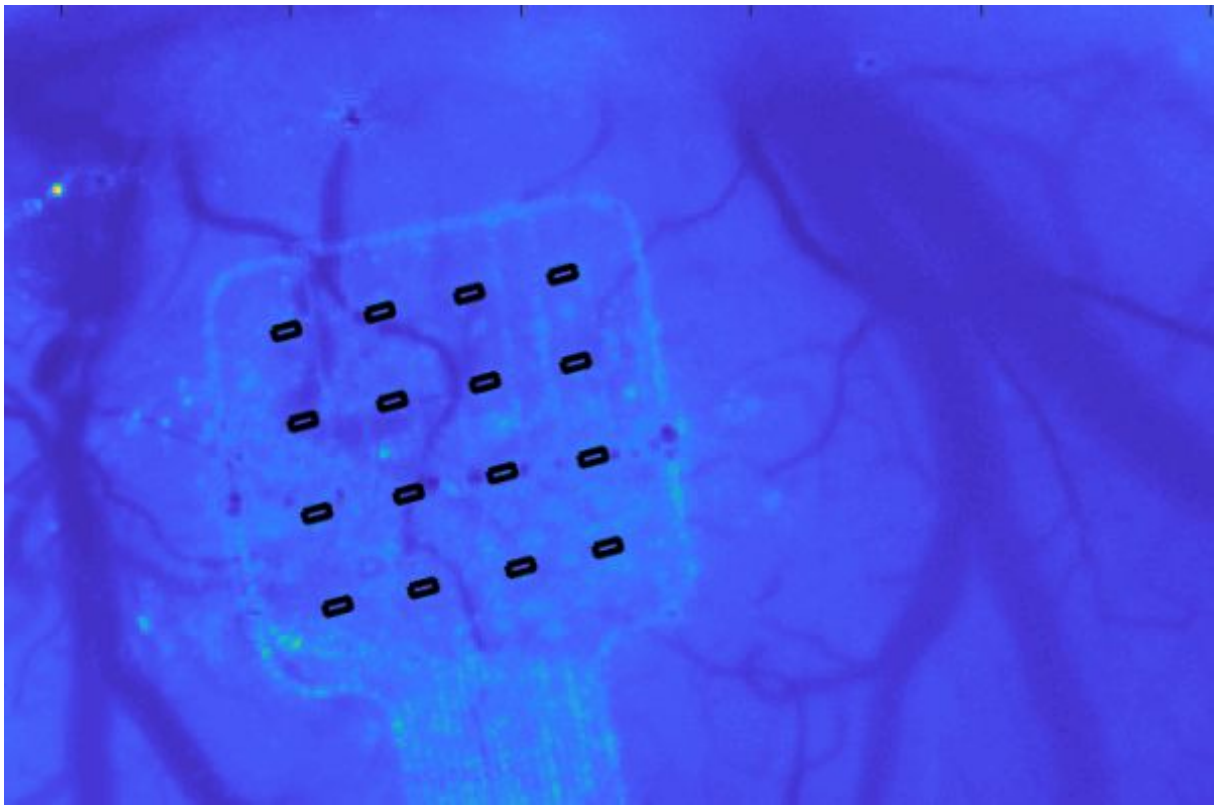

Graphene-based implant for record brain activity at extremely low frequencies

ICN2, IMB-CNM, CSIC, IDIBAPS, and ICFO report in Nature Materials a graphene-based implant able to record electrical activity in the brain at extremely low frequencies and over large areas.

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The body of knowledge about the human brain is growing exponentially, but questions big and small remain unanswered. Researchers have been using electrode arrays to record the brain?s electrical activity for decades, mapping activity in different brain regions to understand what it looks like when everything is working, and what is happening when it is not. Until now, however, these arrays have only been able to detect activity over a certain frequency threshold. A new technology developed in Barcelona overcomes this technical limitation, unlocking the wealth of information found below 0.1 Hz, while at the same time paving the way for future brain-computer interfaces.

Developed at the Barcelona Microelectronics Institute (IMB-CNM, CSIC) and the Catalan Institute of Nanoscience and Nanotechnology (ICN2, a center of BIST and CSIC), and the CIBER in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), and adapted for brain recordings in collaboration with the August Pi i Sunyer Biomedical Research Institute (IDIBAPS), the technology moves away from electrodes and uses an innovative transistor-based architecture that amplifies the brain?s signals in situ before transmitting them to a receiver. Furthermore, the use of graphene to build this new architecture means the resulting implant can support many more recording sites than a standard electrode array, plus is slim and flexible enough to be used over large areas of the cortex without being rejected or interfering with normal brain function. The result is an unprecedented mapping of the kind of low frequency brain activity known to carry crucial information about different events in the brain such as the onset and progression of epileptic seizures and strokes.

For neurologists this means they finally have access to the brain?s whispered clues. Prof. Matthew Walker, of University College London and world specialist in clinical epilepsy, has called it a ground-breaking technology that has the potential to change the way we record and view electrical activity from the brain. Future applications will give unprecedented insights into where and how seizures begin and end, enabling new approaches to the diagnosis and treatment of epilepsy.

Beyond epilepsy, though, this precise mapping and interaction with the brain has other exciting applications. Taking advantage of the capability of the transistor configuration to create arrays with a very large number of recording sites, by employing a so-called multiplexing strategy, the technology described here is also being adapted by some of the same researchers to restore speech and communication as part of the European project, BrainCom. Led by the ICN2, this project will deliver a new generation of brain-computer interfaces able to explore and repair high-level cognitive functions, with a particular focus on the kind of speech impairment caused by brain or spinal cord injuries (aphasia).

Details of the underlying technological advances (patent pending) can be found in Nature Materials, with lead author Eduard Masvidal Codina of IMB-CNM, CSIC. Work at this institute was led by Dr Anton Guimera Brunet, while ICREA Prof. Jose A Garrido led efforts at the ICN2. The graphene microtransistors were adapted for brain recordings and tested in vivo at IDIBAPS, led by ICREA Prof. Mavi Sanchez-Vives. An imaging technique was developed in collaboration with ICFO, led by ICREA Prof. Turgut Durduran. The project is co-funded by the Graphene Flagship and the BrainCom project.