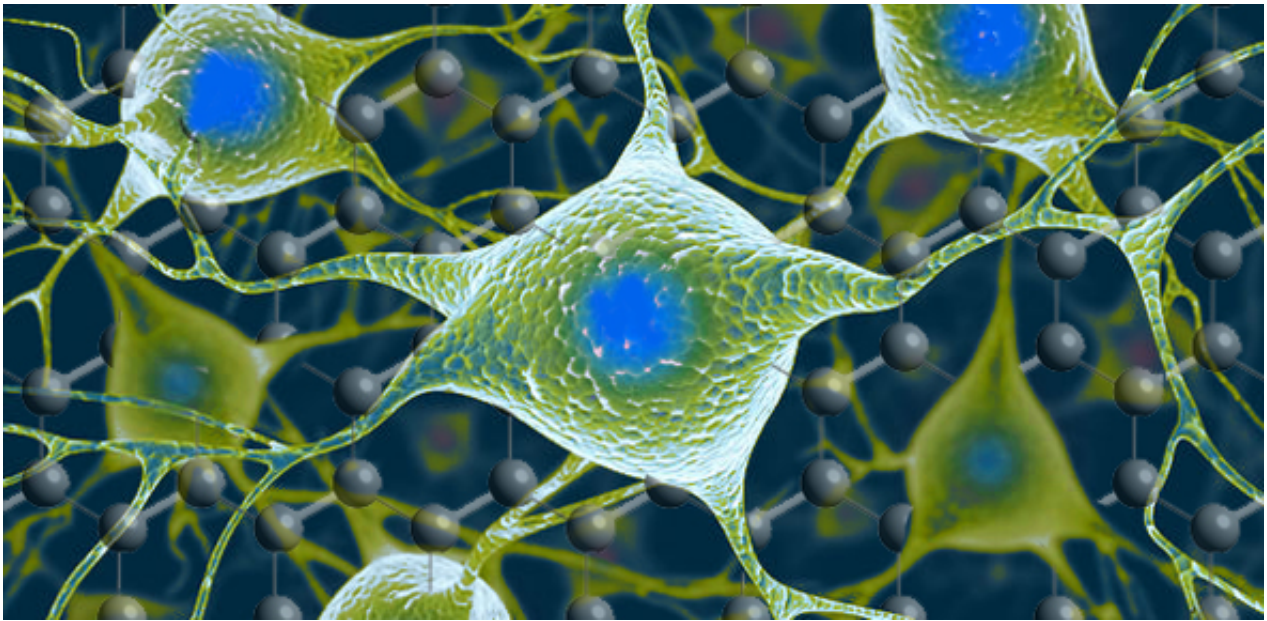


Graphene shown to safely interact with neurons in the brain



Researchers have shown that graphene can be used to make electrodes that can be implanted in the brain, which could potentially be used to restore sensory functions for amputee or paralysed patients, or for individuals with motor disorders such as Parkinson's disease.

Researchers have successfully demonstrated how it is possible to interface graphene – a two-dimensional form of carbon – with neurons, or nerve cells, while maintaining the integrity of these vital cells. The work may be used to build graphene-based electrodes that can safely be implanted in the brain, offering promise for the restoration of sensory functions for amputee or paralysed patients, or for individuals with motor disorders such as epilepsy or Parkinson's disease.

We are just at the tip of the iceberg when it comes to the potential of graphene and related materials in bio-applications and medicine.

— Andrea Ferrari

The [research \(http://pubs.acs.org/doi/abs/10.1021/acsnano.5b05647\)](http://pubs.acs.org/doi/abs/10.1021/acsnano.5b05647) , published in the journal *ACS Nano*, was an interdisciplinary collaboration coordinated by the University of Trieste in Italy and the Cambridge Graphene Centre.

Previously, other groups had shown that it is possible to use treated graphene to interact with neurons. However the signal to noise ratio from this interface was very low. By developing methods of working with untreated graphene, the researchers retained the material's electrical conductivity, making it a significantly better electrode.

"For the first time we interfaced graphene to neurons directly," said Professor Laura Ballerini of the University of Trieste in Italy. "We then tested the ability of neurons to generate electrical signals known to represent brain activities, and found that the neurons retained their neuronal signalling properties unaltered. This is the first functional study of neuronal synaptic activity using uncoated graphene based materials."

Our understanding of the brain has increased to such a degree that by interfacing directly between the brain and the outside world we can now harness and control some of its functions. For instance, by measuring the brain's electrical impulses, sensory functions can be recovered. This can be used to control robotic arms for amputee patients or any number of basic processes for paralysed patients – from speech to movement of objects in the world around them. Alternatively, by interfering with these electrical impulses, motor disorders (such as epilepsy or Parkinson's) can start to be controlled.

Scientists have made this possible by developing electrodes that can be placed deep within the brain. These electrodes connect directly to neurons and transmit their electrical signals away from the body, allowing their meaning to be decoded.

However, the interface between neurons and electrodes has often been problematic: not only do the electrodes need to be highly sensitive to electrical impulses, but they need to be stable in the body without altering the tissue they measure.

Too often the modern electrodes used for this interface (based on tungsten or silicon) suffer from partial or complete loss of signal over time. This is often caused by the formation of scar tissue from the electrode insertion, which prevents the electrode from moving with the natural movements of the brain due to its rigid nature.

Graphene has been shown to be a promising material to solve these problems, because of its excellent conductivity, flexibility, biocompatibility and stability within the body.

Based on experiments conducted in rat brain cell cultures, the researchers found that untreated graphene electrodes interfaced well with neurons. By studying the neurons with electron microscopy and immunofluorescence the researchers found that they remained healthy, transmitting normal electric impulses and, importantly, none of the adverse reactions which lead to the damaging scar tissue were seen.

According to the researchers, this is the first step towards using pristine graphene-based materials as an electrode for a neuro-interface. In future, the researchers will investigate how different forms of graphene, from multiple layers to monolayers, are able to affect neurons, and whether tuning the material properties of graphene might alter the synapses and neuronal excitability in new and unique ways. "Hopefully this will pave the way for better deep brain implants to both harness and control the brain, with higher sensitivity and fewer unwanted side effects," said Ballerini.

"We are currently involved in frontline research in graphene technology towards biomedical applications," said Professor Maurizio Prato from the University of Trieste. "In this scenario, the development and translation in neurology of graphene-based high-performance biodevices requires the exploration of the interactions between graphene nano- and micro-sheets with the sophisticated signalling machinery of nerve cells. Our work is only a first step in that direction."

"These initial results show how we are just at the tip of the iceberg when it comes to the potential of graphene and related materials in bio-applications and medicine," said Professor Andrea Ferrari, Director of the Cambridge Graphene Centre. "The expertise developed at the Cambridge Graphene Centre allows us to produce large quantities of pristine material in solution, and this study proves the compatibility of our process with neuro-interfaces."

The research was funded by the Graphene Flagship, a European initiative which promotes a collaborative approach to research with an aim of helping to translate graphene out of the academic laboratory, through local industry and into society.

Reference:

Fabbro A., et. al. 'Graphene-Based Interfaces do not Alter Target Nerve Cells (<http://pubs.acs.org/doi/abs/10.1021/acsnano.5b05647>) .' ACS Nano (2016). DOI: 10.1021/acsnano.5b05647



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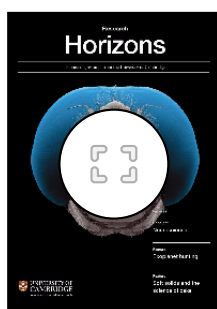
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