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03 Oct 2024 | **Interviews**

Inbrain Has Sights On Parkinson's Following First-In-Human Test Of Graphene-Based Implant

by Marion Webb

Spain-based Inbrain Neuroelectronics plans first-in-human study to show safety of its graphene-based technology in direct contact with human brain while also developing a second interface for treating Parkinson's disease.

Inbrain Neuroelectronics reached a major milestone by announcing that surgeons at the University of Manchester, for the first time, used its graphene-based neural technology during a human brain surgery. The Spain-based brain-computer interface (BCI) developer plans to test its graphene device in up to 10 patients undergoing brain cancer surgery to show that graphene is safe when it comes in direct contact with the human brain, which it hopes will pave the way for eventual commercialization of a product that can do neural decoding and serve as a therapeutic.

Carolina Aguilar, CEO of Inbrain, believes the company is at the forefront of developing a graphene-based BCI therapeutic for treating neurological disorders such as Parkinson's disease. It has been 10 years since Andre Geim and Konstantin Novoselov, an advisor for Inbrain, first isolated graphene at the University of Manchester. The breakthrough discovery won Geim and Novoselov the Nobel Prize in physics in 2010.

Graphene has been used in solar cells, batteries and nuclear power plants and is seen as having potentially wide applications in medicine, such as carrying chemotherapy to tumors in cancer patients and for cancer detection. But Inbrain's 26 September announcement marks the first use of graphene in a BCI procedure.

Graphene, consisting of a single layer of carbon atoms arranged in a hexagonal lattice, is the thinnest material known to science, yet 200 times stronger than steel. Graphene's properties are also remarkable in that it is highly conductive, biocompatible, and flexible.

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InBrain

The University of Manchester is part of the *Graphene Flagship*, a project launched in 2013 by the European Commission with a budget of €1bn over 10 years, that has mobilized 150 academic and industrial research groups to "take graphene and related materials from academic laboratories to society within 10 years, while revolutionizing entire industries and creating economic growth and new jobs in Europe." Aguilar told *Medtech Insight*, "We are aiming to have a commercial product that can do brain decoding and brain mapping and could be used in a variety of disorders," Aguilar told *Medtech Insight*.

Decoding, Mapping

Co-founded in 2020 by Aguilar, Kostas Kostarelos, and Jose Garrido, chief scientific officer at Inbrain, Inbrain raised $17m in a series A funding round in March 2021. The round was co-led by Asabys Partners and Alta Life Sciences and joined by Vsquared Ventures and TruVenturo GmbH, with participation of the Spanish Ministry of Science's CDTI Innovación (Centre for Technology Development and Innovation) and a follow-on investment by the Institut Català de Finances' ICF Venture Tech II fund.

Last week, the company announced that surgeons at the Salford Royal Hospital in Manchester, UK, used Inbrain's BCI technology in a patient undergoing a brain tumor resection to do brain mapping, a technique used to help plan brain surgeries.

When surgeons remove a brain tumor, they place electrodes on the brain to identify and protect critical regions such as those responsible for language, motor and sensory function. During the heralded surgery, Inbrain's cortical implant was installed for 79 minutes. In that time, surgeons observed that the cortical interface was able to differentiate between healthy and cancerous brain tissue with micrometer-scale precision.

David Coope, the neurosurgeon who performed the surgery, says Inbrain's technology was able to capture brain activity where traditional metals and other materials struggle with fidelity.

Synchron Announces Positive Results From Stentrode BCI Study, Plans For Pivotal Study

By Marion Webb

"Graphene provides ultra-high density for sensing and stimulating, which is critical to conduct high-precision resections while preserving the patient's functional capacities, such as

movement, language or cognition," Coope said in a statement.

Inbrain's graphene-based chip is manufactured on a wafer using standard semiconductor techniques and is ultra-thin at 10 micrometers – "just like a bundle of hair," Aguilar said.

30 Sep 2024
After announcing positive results showing that its Stentrode BCI is safe in six patients, brain-computer interface company Synchron is planning a pivotal trial to eventually file for FDA approval.

Read the full article here

It is also bi-directional, meaning it has the ability to record from the brain – and as such act like a communication device for people who can't speak and use external devices – as well as stimulate the brain, which Inbrain hopes will translate into a therapeutic tool to help people with Parkinson's and other neurological disorders control movements. Aguilar is confident that bidirectionality will give Inbrain a competitive edge on the marketplace. Inbrain is one of several companies working on BCI technology, but differs from many other BCIs by harnessing the power of graphene and targeting to restore mobility in patients with disabilities such as Parkinson's disease. (Also see "*News We're Watching: Neuralink's Blindsight Gets FDA Breakthrough Device Tag; FDA Pump Recalls, Guidances; Discure, DeepLook Bolster Coffers*" - Medtech Insight, 20 Sep, 2024.)

Inbrain's planned up to10-patient clinical trial is primarily intended to show the safety of graphene in direct contact with the human brain. But the company also aims to demonstrate graphene's superiority over other materials in decoding brain functionality in both awake and sleep states, she said.

"There are exploratory objectives on speech decoding, motor decoding – so more on the BCI spectrum – to show that indeed we can do what the other [BCIs] can do," she said. For instance, the patient will be asked during the procedure to perform certain language tasks, which will be decoded by the device. Aguilar expects the trial to last less than 12 months and hopes to bring the interface to the market in the next two years, pending regulatory approval.

Key Takeaways

- Inbrain's graphene-based brain-computer interface (BCI) technology was successfully used in human brain surgery for the first time, aiming to show graphene's safety.
- The company's graphene-based implants target neurological conditions like Parkinson's, offering more precise and

Inbrain's commercialization strategy is to pursue US Food and Drug Administration

approval first, not least of all because in the US the cortical implant is classified as a Class II medical device (moderate risk) versus a Class III (high risk) product in Europe, Aguilar said.

"The regulatory path is more straightforward in the US right now," she said, adding, "We will collect data to also submit in Europe."

adaptive treatments compared to current deep brain stimulation (DBS) systems.

- Inbrain is focused on obtaining FDA approval, with plans to commercialize its BCI technology within two years, pending trial results and regulatory approval.

Therapy For Neurological Disorders

As trials continue using Inbrain's cortical interface, the company also will continue developing a second subcortical implant, which penetrates the brain tissue and can deliver precise electrical stimulation. Eventually, the company plans to integrate both implants and test them together as a treatment for neurological disorders, starting with Parkinson's disease.

Using the cortical and subcortical implants together will allow for decoding movement intention, for example to move the right or left leg. When the system identifies freezing gait, a common and disabling symptom of Parkinson's disease, the device would "desynchronize gait and normalize walk," Aguilar said.

Inbrain's Intelligent Network Decoding & Modulation (BCI-Tx) platform was granted an FDA Breakthrough Device Designation in September 2023 as an adjunctive therapy for treating Parkinson's disease.

"Parkinson's is a very big market where I think current therapies are not as effective as they could be," Aguilar said. "There are also reimbursement codes and all the ingredients to prove superiority, whereas in other markets everything needs to be build."

Deep brain stimulation (DBS), involves an implanted device that delivers electrical current to a targeted part of the brain, has shown to be effective for treating conditions like Parkinson's disease in some people.

But Aguilar believes Inbrain's technology could be more effective than DBS by providing stimulation only when needed so the effects do not wear off, as is often the case with DBS therapies.

For example, Inbrain could improve on current DBS systems by decoding biomarkers associated with symptoms related to motor function and then deliver stimulation as needed. She noted that 40% of Parkinson's patients treated with DBS still have freezing gait – "We want to fix those

things that aren't fixable by DBS devices," she said.

Helen Bronte Stewart, a professor of neurology at Stanford University School of Medicine involved with Inbrain, says current leads, which are insulated wires with multiple electrodes implanted in the brain, are limited by their relatively large size and low density, which inhibit precision targeting of small, deep structures. In her view, Inbrain's graphine-based, high-resolution interfaces and network platform "may vastly improve the precision, efficiency and efficacy of DBS and closed-loop or adaptive modulation."

> *"We want to fix those things that aren't fixable by DBS devices" – Carolina Aguilar*

For FDA approval, Inbrain has to show "reliability of the device for at least 10 years," but the company aims to do better than that, Alguilar said.

On an accelerated timeline, "We want to show what graphene and the system can do is of highest effectiveness of what current technology and therapies can do," she said.

Asked when Inbrain's second product could reach the market, Aguilar said the company is meeting with the FDA every month as part of the Total Product Life Cycle Advisory Program (TAP). The voluntary TAP program was launched by the agency's Center for Devices and Radiological Health last year to help spur development of safe, effective and innovative medical devices critical to public health. (Also see "*FDA Begins 'Soft' TAP, Will Phase In Pilot Over Five Years*" - Medtech Insight, 4 Jan, 2023.)

Aguilar expects the commercial version of its implant will have 1,024 electrodes, boasting significantly more power than the current 100-electrode model. The more electrodes, the more information that can be extracted from the brain.

Aguilar believes the company's interfaces may also have applications for treating stroke and epilepsy.

"This market has been highly driven by the US – we want to partner and drive this also from this side of the ocean because there is a huge need as well," she added. "We want to be one of those European moonshots with global reach."