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‘Shrink Wrap’ implant melts onto surface of the brain

By Darren Quick

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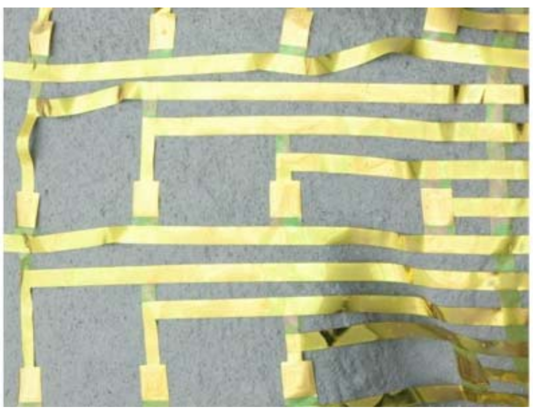

Neural electrode array wrapped onto a model of the brain after dissolution of a thin, supporting base of silk (Image: C. Conway and J. Rogers, Beckman Institute)

The same team responsible for the development of a flexible silicon device that wraps around a heart to record its electrical activity has now developed a brain implant that essentially melts into place, snugly fitting to the brain's surface. Such ultrathin flexible implants, made partly from silk, can record brain activity more faithfully than thicker implants embedded with similar electronics and could pave the way for better devices to monitor and control seizures, and to transmit signals from the brain past damaged parts of the spinal cord.

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The simplest devices for recording from the brain are needle-like electrodes that can penetrate deep into brain tissue. More state-of-the-art devices, called micro-electrode arrays, consist of dozens of semi-flexible wire electrodes, usually fixed to rigid silicon grids that do not conform to the brain's shape.

In comparison the new implants contain metal electrodes that are 500 microns thick, or about five times the thickness of a human hair. The absence of sharp electrodes and rigid surfaces found on current brain implants should improve safety, with less damage to brain tissue. Also, the implants' ability to mold to the brain's surface could provide better stability. If the brain shifts in the skull, the implant could move with it. Finally, by spreading across the brain, the implants have the potential to capture the activity of large networks of brain cells.

Besides its flexibility, silk was chosen as the base material because it is durable enough to undergo patterning of thin metal traces for electrodes and other electronics. It can also be engineered to avoid inflammatory reactions, and to dissolve at controlled time points, from almost immediately after implantation to years later. The electrode arrays can be printed onto layers of polyimide (a type of plastic) and silk, which can then be positioned on the brain.

"The focus of our study was to make ultrathin arrays that conform to the complex shape of the brain, and limit the amount of tissue damage and inflammation," said Brian Litt, M.D., an author on the study and an associate professor of neurology at the University of Pennsylvania School of Medicine in Philadelphia. The silk-based implants developed by Dr. Litt and his colleagues can hug the brain like shrink wrap, collapsing into its grooves and stretching over its rounded surfaces.

In people with epilepsy, the arrays could be used to detect when seizures first begin, and deliver pulses to shut the seizures down. In people with spinal cord injuries, the technology has promise for reading complex signals in the brain that direct movement, and routing those signals to healthy muscles or prosthetic devices.

To make and test the silk-based implants, Dr. Litt collaborated with scientists at the University of Illinois in Urbana-Champaign and at Tufts University outside Boston. John Rogers, Ph.D., a professor of materials science and engineering at the University of Illinois, invented the flexible electronics. David Kaplan, Ph.D., and Fiorenzo Omenetto, Ph.D., professors of biomedical engineering at Tufts, engineered the tissue-compatible silk. Dr. Litt used the electronics and silk technology to design the implants, which were fabricated at the University of Illinois.

In the study, the researchers approached the design of a brain implant by first optimizing the mechanics of silk films and their ability to hug the brain. They tested electrode arrays of varying thickness on complex objects, brain models and ultimately in the brains of living, anesthetized animals.

The arrays consisted of 30 electrodes in a 5x6 pattern on an ultrathin layer of polyimide – with or without a silk base. These experiments led to the development of an array with a mesh base of polyimide and silk that dissolves once it makes contact with the brain.

Next, they tested the ability of these implants to record the animals' brain activity. By recording signals from the brain's visual center in response to visual stimulation, they found that the ultrathin polyimide-silk arrays captured more robust signals compared to thicker implants.

In the future, the researchers hope to design implants that are more densely packed with electrodes to achieve higher resolution recordings.

"It may also be possible to compress the silk-based implants and deliver them to the brain, through a catheter, in forms that are instrumented with a range of high performance, active electronic components," Dr. Rogers said.

The study, "Dissolvable Films of Silk Fibroin for Ultrathin Conformal Bio-Integrated Electronics," is published in the journal, *Nature Materials*.

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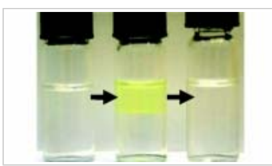

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