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Flexible Electronics Injected Into Mouse Brains

Bioelectronics: Researchers use syringes to insert submicron-thick mesh electronics to record neuron activity in living animals

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Syringes deliver drugs, vaccines, and cells deep into the tissues of animals and people. Now a study adds electronic devices to that list.

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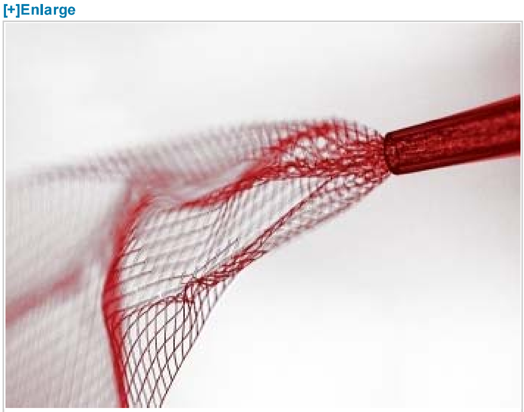

A mesh electronic (red) spills out of a glass needle with a diameter less than 100 μm.

Credit: Lieber Research Group/Harvard U

A team of researchers report extremely flexible, centimeter-wide mesh electronics that they can inject into the brains of mice, allowing them to record neuron activity without damaging surrounding tissue. These devices could lead to improved neural implants that interact with brain tissue to treat diseases such as Parkinson's or to help neuroscientists study brain circuitry.

The new devices "will likely change how we think about the possibilities when merging electronics with tissue" and could lead to interesting new technologies, says Michael R. Bruchas, a neurobiologist at Washington University in St. Louis who was not involved in the work.

Brain implants are already approved by the Food & Drug Administration to treat some forms of Parkinson's disease and other neurological illnesses.

Despite the success of these implants, they all have a significant limitation, says Charles M. Lieber of Harvard University. Their mechanical properties, such as flexibility, do not match those of the brain tissue surrounding them. So when the brain moves in the skull, the devices don't respond the same way the tissue does. This leads to the implant rubbing against the tissue, causing cell damage that elicits an immune response. These reactions can build up scar tissue around the implant, affecting device performance.

The new electronic devices, developed by Lieber and colleagues, are 10,000 to 1 million times as flexible as previously reported implantable devices. A month after the researchers injected the new devices into mouse brains, they saw little to no sign of a reaction. For instance, neuron density around the electronics remained unchanged (*Nat. Nanotechnol.* 2015, DOI: 10.1038/nnano.2015.115).

To achieve this extreme flexibility, the team made the electronics significantly thinner than previous devices—0.8 μm versus more than 10 μm. The mesh structure, which Lieber describes as a version of chicken wire, is also less stiff than the continuous sheets of polymer used in other devices.

The new implants consist of thin gold wires encapsulated by a biocompatible polymer. These wires intersect across the mesh, forming a series of tiled parallelograms. This design allows the devices to roll up when sucked into a syringe and then easily flow out the needle when injected into tissue. In fact, the team could inject mesh electronics that were more than 30 times as wide as the internal diameter of a needle without clogging.

The ability to inject the electronics, instead of implanting them via surgery, allows "for reaching deeper brain structures or harder-to-reach places than more traditional electronic implants can," Bruchas says. "It could allow for integration or sensing of brain regions that have been previously difficult to interact with."

Lieber says his team is now testing the biocompatibility of the mesh for periods longer than a month. The researchers also plan to investigate applications such as recording activity from single neurons in the retina of mice and co-injecting the mesh with stem cells to see whether they can regenerate tissue in mice that have had strokes.

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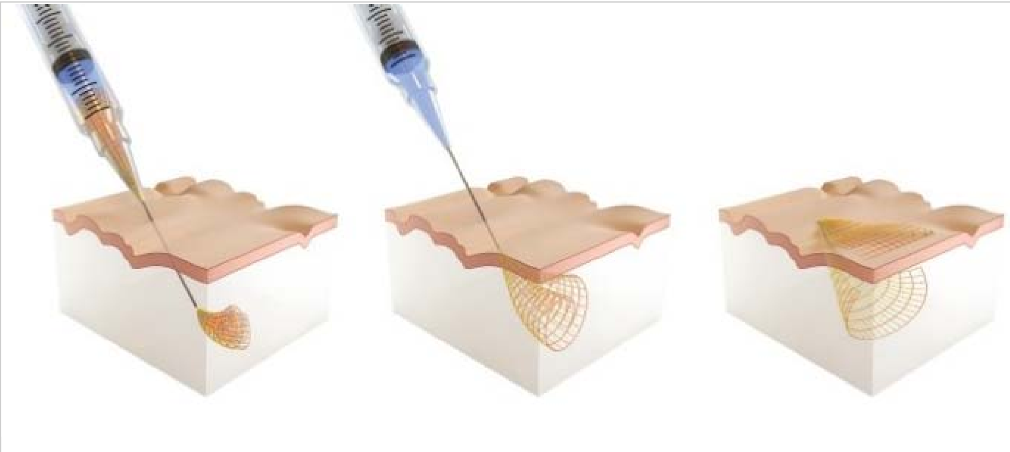

To inject a mesh electronic into tissue, researchers push a needle to the desired depth (left). They eject the device at the same rate as they withdraw the needle, allowing the mesh to unfold (center). This draws a piece of the device outside the tissue (right) for connection to external electronics.

Credit: *Nat. Nanotechnol.*

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