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May/June 2010

TR10: Implantable Electronics

Dissolvable devices make better medical implants.

By [Katherine Bourzac](#)

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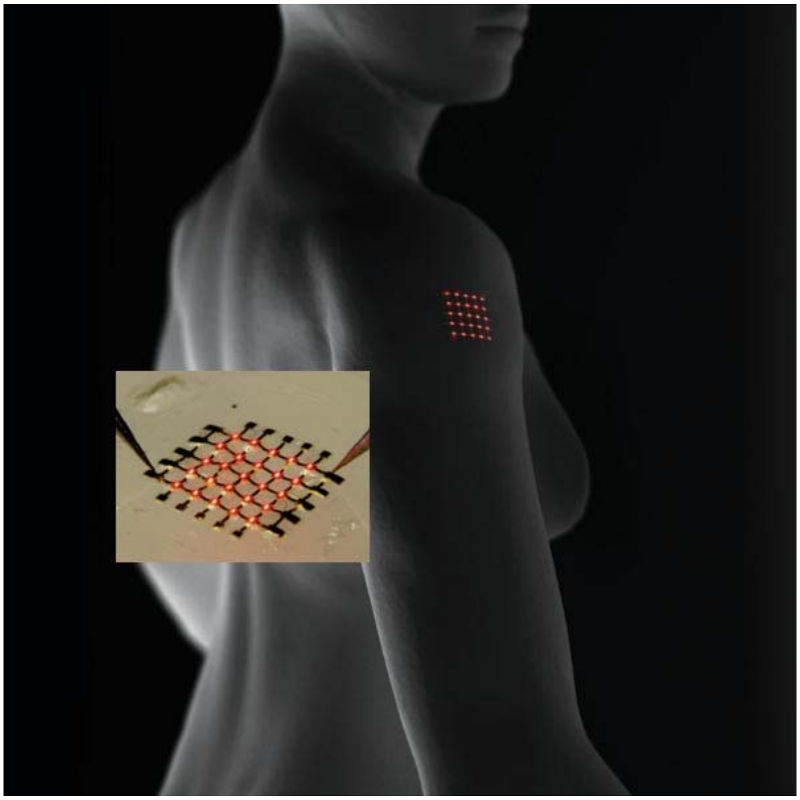

Implanted under the skin, an array of light-emitting diodes could signal the concentration in the blood of biomarkers such as insulin. Over time, the array will dissolve away, eliminating the need for surgery to remove the implant. Flexible silicon electronics (inset) are held in place with a silk film. Incorporating antibodies or enzymes into the film will allow devices to detect biomarkers. Credit: Bryan Christie Design

The next generation of implantable medical devices will rely on a high-tech material forged not in the foundry but in the belly of a worm. Tufts University biomedical engineer Fiorenzo Omenetto is using silk as the basis for implantable optical and electronic devices that will act like a combination vital-sign monitor, blood test, imaging center, and pharmacy--and will safely break down when no longer needed.

Implanted electronics could provide a clearer picture of what's going on inside the body to help monitor chronic diseases or progress after surgery, but biocompatibility issues restrict their use. Many materials commonly used in electronics cause immune reactions when implanted. And in most cases today's implantable devices must be surgically replaced or removed at some point, so it's only worth using an implant for critical devices such as pacemakers. Silk, however, is biodegradable and soft; it carries light like optical glass; and while it can't be made into a transistor or an electrical wire, it can serve as a mechanical support for arrays of electrically active devices, allowing them to sit right on top of biological tissues without causing irritation. Depending on how it's processed, silk can be made to break down inside the body almost instantly or to persist for years. And it can be used to store delicate molecules like enzymes for a long time.

Multimedia

[Watch Omenetto discuss and show how he develops implantable electronics.]

Fiorenzo Omenetto
(Tufts) Biodegradable electronics could make implantable devices easier on the body

OTHERS WORKING ON IMPLANTABLE ELECTRONICS
John Rogers, University of Illinois Urbana-Champaign, IL
Zhenan Bao, Stanford University, Stanford, CA

Current Issue

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Omenetto began working with silk three years ago, when David Kaplan, a biomedical engineer across the hall, asked for help making the material into complex scaffolds for growing new tissues. He boils silkworm cocoons and purifies the resulting solution to create his master ingredient, a water-based solution of the silk protein called fibroin. This solution can be poured into molds to make structures whose features are as small as 10 nanometers across. Omenetto has molded it into a wide variety of optical devices, such as lenses, mirrors, prisms, and optical fibers, all of which could be used to direct light to and from biosensors implanted in the body. Mixing antibodies or enzymes into the silk solution before molding it results in devices that could someday be used to sense low concentrations of just about any biological molecule, from glucose to tumor markers.

Collaborating with Kaplan and materials scientist John Rogers at the University of Illinois at Urbana-Champaign, Omenetto has produced implants that combine silk with flexible silicon electronics. For instance, the group has used silk films to hold in place arrays of tiny silicon transistors and LEDs--a possible basis for implantable devices that will help identify the concentration of disease markers. The researchers have shown that the devices function fine in small animals, with no evidence of scarring or immune response. The silk dissolves, leaving behind a small amount of silicon and other materials used in the circuits.

Story continues below

Another device uses silk as a substrate for a metal electrode mesh designed to replace spike-like electrodes used on the surface of the brain to diagnose and treat conditions such as epilepsy. When doused with saline solution, the silk wraps the mesh around the surface of the brain (even tucking it into the creases), helping the electrodes measure neural activity more precisely. The silk-based electrodes will probably be the first of the group's devices to be tested in people, perhaps in two to three years.

Omenetto sees other possibilities further in the future: for example, a silk optical fiber could transmit light from an LED array to an implanted silk sensor, which would change color to indicate that a cancer has come back. The device might then release a precisely calibrated dose of a drug. A second silk fiber could transmit that information to the surface of the patient's skin, where the output might be read by a cell phone. All the components for making such things exist, Omenetto says. Once the pieces are brought together, a little silk will help save lives.

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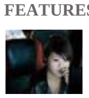

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By David Talbot

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