New 'transient electronics' disappear when no longer needed

April 8 2013

Scientists today described key advances toward practical uses of a new genre of tiny, biocompatible electronic devices that could be implanted into the body to relieve pain or battle infection for a specific period of time, and then dissolve harmlessly.

These "transient electronics," described here at the 245th National Meeting & Exposition of the American Chemical Society (ACS), could have other uses, including consumer electronics products with a pre-engineered service life. The meeting, which features almost 12,000 reports on new scientific advances and other presentations, continues through Thursday.

John Rogers, Ph.D., who led the research, explained that it arises from a view of electronics fundamentally different from the mindset that has prevailed since the era of electronic "chips," integrated circuits and microprocessors, which dawned almost 50 years ago.

"The goal of the electronics industry has always been to build durable devices that last forever with stable performance," Rogers explained. "But many new opportunities open up once you start thinking about electronics that could disappear in a controlled and programmable way."

Those opportunities, he added, include cell phones and other mobile devices that stop working on a timetable corresponding to the time for upgrading to a new model. Instead of adding to the $50 million of so-called e-waste generated every year, the devices would simply break

down. Medical implants that are only needed for a few weeks could just disappear, without requiring an extra surgery to remove them from the body. And no one would have to retrieve dozens of transient water-quality sensors from a river undergoing water quality monitoring. They would dissolve without a trace and without harm to the environment.

Although other researchers have developed so-called bioresorbable medical devices that disappear over time in the body, Rogers' team at the University of Illinois at Urbana-Champaign is the first to produce such broadly applicable technology, which has many more potential uses than other devices. The scientists have designed transient electronics as temperature sensors, solar cells and miniature digital cameras, for instance. Moreover, previous bioresorbable devices were made of different materials that only partially dissolved, leaving behind residues, and they did not perform as well as Rogers' current devices.

The electronics are enclosed in material that dissolves completely after a certain period of time when exposed to water or body fluids, somewhat like dissolvable sutures. By altering the number of layers of the wrapping, scientists can define everything about how the device will dissolve in the body or in the environment, including its overall lifetime, said Rogers. The devices perform just as well as conventional electronics and function normally until the encapsulating layer disappears. Once that happens, it takes about 30 minutes for the electronic connections to dissolve away, and the device stops working. Current versions of the devices remain operable for a few weeks. Rogers' team is researching ways to make devices that last a few years.

In his ACS report, Rogers described key advances in the technology. One advance established for the first time that transient electronic devices, implanted into laboratory mice, actually work in battling infections and do, indeed, dissolve when done. Rogers' team previously only thought that would happen. The devices produced localized heat,

which prevented bacterial growth and surgery-related infections from developing in the mice. The findings add to the confidence that similar devices can be designed to reduce pain by stimulating certain nerves or facilitate bone growth or wound healing.

The scientists also reported progress in making the devices with conventional manufacturing processes instead of meticulously building the electronics one-by-one by hand in a laboratory. "It's a step toward producing these devices with the kind of manufacturing processes that are already in wide use for traditional electronics like silicon-based microprocessors and memory technology," said Rogers.

Another advance involved the materials for making and powering the devices without an external electricity source. Rogers said, for instance, that the latest transient electronic devices incorporate zinc oxide, which is "piezoelectric." It means that thin, flexible devices made with zinc oxide could produce electricity when bent or twisted—perhaps by movement of muscles in the body, pulsation of blood vessels or beating of the heart.

More information: Abstract

A characteristic feature of modern silicon integrated circuit technology is its ability to operate in a stable, reliable fashion, almost indefinitely for practical purposes. Recent work demonstrates that carefully selected sets of materials and device designs enable a class of silicon electronics that has the opposite behavior—it physically disappears in water or biofluids, in a controlled manner, at programmed times. This talk summarizes recent work on this type of 'transient' electronics technology, ranging from basic studies of dissolution of the key materials, to development of components and systems with radio frequency operation, to invention of schemes for externally 'triggering' transient behavior.

Provided by American Chemical Society