Transient Electronics That Disappear

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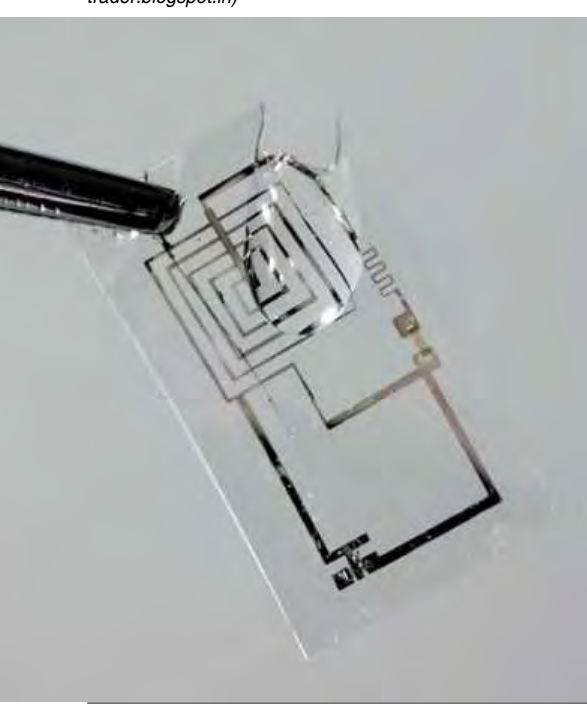
In this era of electronics-driven lifestyle with well-established advantages of durable, long-lasting electronics, and when the use of electronic devices has invaded into the human body itself, thinking about transient electronics (that dissolve after some time without leaving a trace) and its applications is inevitable.

Millions of patients have benefited from the innovative development of electronic medical devices/gadgets such as pacemakers or medicine-dispensing agents implanted in the body for either diagnostic or therapeutic benefits. While these have revolutionised modern medicine, many a time these outlive their purpose in the human body and require surgical removal to avoid complication. However, rather than removing these devices through surgery, what if these could simply disappear?

This is the concept behind transient electronics, the newly-developed electronic devices that are designed to dissolve inside the body once these have served their purpose. Transient electronics offer robust performance, which is comparable to current devices, but these completely resorb into their environment at a prescribed time, ranging from minutes to years, depending on the application.



A transient electronic device (Image courtesy: rational-trader.blogspot.in)

The goal of the electronics industry has been to build durable devices that last long with stable performance, but many new opportunities open up once we start thinking about electronics that could disappear in a controlled and programmable way. It is the new way of looking at electronics. Scientists and engineers are developing transient materials, which are special degradable polymer composite materials designed to quickly and completely melt away when a trigger is activated.

The technology could be useful for any application in which sensitive data is used. Some of these are military electronics equipment, credit cards and passports, and any application in which the electronic device is to be used for a defined period of time such as in bioelectronics, implantable electronics and environmental monitoring applications.

Development status

Previous research in the area has explored the use of transient materials to create dissolvable devices such as transistors, resistors and diodes. Researchers have also developed and tested transient resistors and capacitors.

The goal of research is to investigate how the rate of transiency could actually be controlled. They are experimenting with a blend of programmable biodegradable and transient insulating polymer films. They have found that by adding gelatin to the mix, dissolution can be slowed, while addition of sucrose speeds up the rate of transiency.

Using these special polymers, researchers were able to build and test an antenna that was capable of sending data and then completely dissolving itself when a trigger was activated. One constant in this experimentation with different composite structures is that the material maintains appropriate physical properties to function as a substrate for electronics.

The researchers are pioneers in the engineering of ultra-thin flexible electronic components. Only a few tens of nanometres thick, these tiny circuits, from transistors to interconnects, readily dissolve in a small amount of water or body fluid, and are harmlessly resorbed or assimilated.

Controlled degradation and transiency of materials is of significant importance in the design and fabrication of degradable and transient biomedical and electronic de-

vices and platforms. Here, synthesis of programmable biodegradable and transient insulating polymer films is reported, which have sufficient physical and chemical properties to be used as substrates for the construction of transient electronics. The composite structure can be used as a means to control the dissolution and transiency rate of the polymer composite film.

The electronics are enclosed in a 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 how long the device will take to dissolve in the body or in the environment, including its overall lifetime.

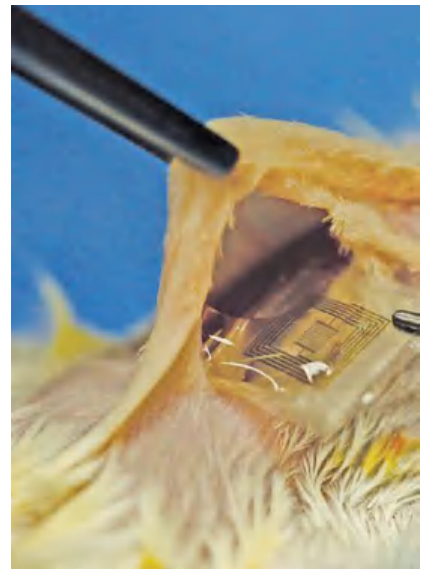
The devices perform just as well as conventional electronics and function normally until the encapsulating layer disappears. Once that happens, it only takes a few minutes for the electronic connections to dissolve away, and the device stops working.

Scientists have also reported progress in making the devices with conventional manufacturing processes instead of meticulously building one-by-one by hand in a laboratory. It is a step towards 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.

Another advancement involved the materials for making and powering the devices without an external electricity source. For example, latest transient electronic devices incorporate zinc-oxide, which is piezoelectric. This 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.

Applications

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



This electronic implant can dissolve inside the body (Image courtesy: rational-trader.blogspot.in)

Scientists have designed transient electronics as temperature sensors, solar cells and miniature digital cameras, for instance. Previous bioresorbable devices were made of different materials that only partially-dissolved, leaving behind residues, and did not perform as well as current devices.

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 now seems possible. A medical device, once its job is done, could harmlessly melt away inside a person's body.

Researchers are now conducting further studies, centred on developing degradable polymer based materials that would make suitable platforms for other electronic components, including work on transient light emitting diode (LED) technology. They have produced a blue LED mounted on a polymer base with electrical leads embedded on it. When it comes into contact with just a drop of water, the base and leads begin to dissolve and the light goes out.

A lost credit card could vanish from existence (but would most likely still leave debt behind), a secret diary could be programmed to self-destruct should it be removed from its hiding spot and sensors stored with food could indicate when it has reached temperatures that would cause the food to spoil.

The real-world application for transient electronics with, perhaps, the most potential is in the field of military strategy, as similar research efforts from DARPA would indicate. If a soldier carrying sensitive information is captured, injured or worse, the electronics could be triggered to melt away before any classified information was gleaned by enemy forces.

A military device could collect and send data contained in it and then dissolve away, leaving no trace of an intelligence mission.

An environmental sensor could collect climate information and then wash away in the rain.

Electronic waste can also be controlled by designing integrated circuits out of materials that are biodegradable.

Dubbed transient electronics, the new class of silk-silicon devices promise a generation of medical implants that would never need surgical removal, as well as environmental monitors and consumer electronics that could become compost rather than trash.

In the future, researchers envision more complex devices that could be adjustable in real-time or are responsive to changes in their environment such as chemistry, light or pressure. Physicians and environmentalists alike could soon be using a new class of electronic devices that are small, robust and provide a high performance, yet are also biocompatible and capable of dissolving completely in water or in bodily fluids. ●