Advance in Electronic and Electric Engineering.
ISSN 2231-1297, Volume 3, Number 7 (2013), pp. 833-838

http://www.ripublication.com/aeee.htm

Transient Electronics

Foram Kamdar

[1]*Department of Electronics and Telecommunications, Mumbai University, Andheri West, Mumbai, INDIA.*

Abstract

The goal of the electronics industry has always been to build durable devices that last forever with stable performance. However, as new technologies like transient electronics are developed, scientists and engineers have the opportunity to develop electronics that could disappear in a controlled or programmed ways.

Transient directly implies anything impermanent i.e. lasting for some time. Transient Electronics is a technology that involves components which physically disappear in whole or in part, at prescribed rates and programmed times. By taking a typical electronic circuit and recreating it as ultrathin model, researchers have created electronic devices that dissolve into their surroundings when no longer required. This paper explains these devices, how they are built, their biocompatibility and ecocompatibility and exactly how they function.

Transient Electronics have an astounding number of applications in life sciences and also consumer electronics. Enabled devices include medical monitors that dissolve that fully resorb when implanted in body (bi-resorable) to avoid long term adverse effects or environmental monitors that dissolve when exposed to water (eco-resorable) to eliminate need for collection and recovery.

Transient Electronics makes medicine more practical, more efficient, and safer and changes the way we handle electronic waste in our environment.

1. Introduction

Researchers at the University of Illinois at Urbana-Champaign and Tufts University have developed biocompatible devices able to serve as conventional electronics but unlike them, they can harmlessly dissolve into fluids. This characteristics opens up a complete array of possible applications like bioresorbable (can be broken down by body, but doesn't require removal) medical implants, degradable environmental monitors and compostable consumer devices. Incorporating silicon from conventional circuits, magnesium as conductor and silk protein for encapsulation of circuit, researchers created these thin electronic devices which can be dissolved into fluids in a programmed manner, called Transient Electronics.

John Rogers, the Lee J. Flory-Founder Professor of Engineering at the U. of I., who led the research team said, “We refer to this type of technology as transient electronics. From the earliest days of the electronics industry, a key design goal has been to build devices that last forever – with completely stable performance. But if you think about the opposite possibility – devices that are engineered to physically disappear in a controlled and programmed manner – then other, completely different kinds of application opportunities open up.”

2. Theory and Functioning

Silicon, as used conventionally, does dissolve in bio-fluids but at a rate far too slower than what is suitable for transient electronics. Hence research team created nano-membranes (ultra-thin sheets) of silicon, which are thin enough to melt with few drops of water. With that, they used magnesium electrodes and interconnect, magnesium oxide gate and interlayer dielectrics to build the circuits. These circuits are then encapsulated in silk layers, collected from silkworm cocoons, dissolved and re-crystallized. Dissipation rate is modified by carefully controlling the crystal structure of silk, timescales ranging from few minutes to hours or days or even years.

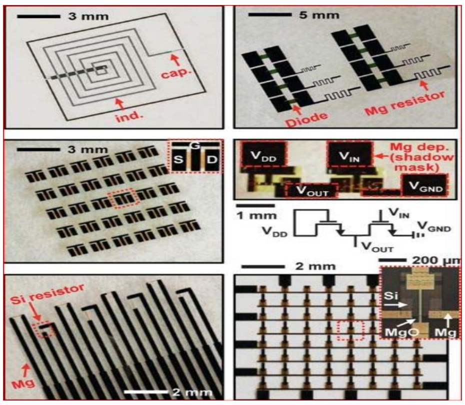

Figure 1: Example of various conventional electronics as transient electronics by www.sciencemag.com.

The electronics inside the silk were based on nanometers-thick sheets or ribbons of silicon, called silicon nanomembranes. The materials have been previously used to make experimental transistors, diodes, complementary logic devices, and photocells for flexible surfaces. Whereas a conventional silicon wafer or a chip would take about a thousand years to dissolve in bio-fluids, says John Rogers, a nanomembrane is gone in a couple of weeks. The researchers tested a host of such transient components like inductors, capacitors, resistors, diodes, and transistors. All the components disintegrated and dissolved when immersed in de-ionized water. The materials and fabrication techniques may be used to make components for electronic systems in complementary metal-oxide semiconductor (CMOS) logic.

The researchers and engineers came up with their invention hoping to address a core problem with medical implants – rejection. ""It's an issue of long term biocompatibility," John Rogers, a professor in the department of mechanical science and engineering at UIUC and a corresponding author on the study, told FoxNews.com. "….We were wondering whether there would be a way to make electronics that would resolve those problems – vanishing after [they've] served [their] useful lifetime. Electronics that are physically transient, so they can [dissolve] in water or biofluids."

Figure 1: Size of around 3mm (courtesy io9.com)

Looking to develop such technology, Rogers and his fellow researchers set about to identify the right materials that would provide high performance, but also be biodegradable. Rogers said that thin sheets of silicon, a common ingredient in modern integrated circuits, were used as semi-conductors.

"[Silicon] is water soluble, but the dissolution rates are so low," Rogers explained, which is why it is a valuable material for electronics. "But these are ultra thin geometries, so those low rates become important." Magnesium, another integrated circuit material, was used as the device's electrode. And for their most unique ingredient, the team utilized purified material from the cocoons of silk worms – an FDA approved material – as a substrate and packaging material.

3. Current Research

The team was able to construct a very tiny biomedical implant in mice, which was used to eliminate a common complication with many surgeries. "That is the growing problem associated with surgery – surgical sight infection," Rogers said. "Infection of that source is the leading cause of readmission to the hospital. It is often times a result of bacteria colonies at the sight of surgery." According to Rogers, the device was a thin sheet of electronic, located at the sight of surgery before the patient – in this case the mouse – before they are closed up.

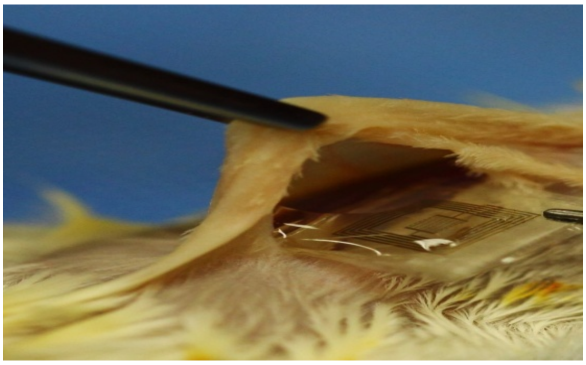

Figure 1: Implantation in rat (courtesy Beckham Institute, Uuniversity of Illinois).

Capable of receiving power wirelessly, the device creates local heating at levels that can kill bacteria that may be forming at the sight of surgery. However, the risk of infection from surgery is the most critical two weeks after the initial period – rendering the device unnecessary in just a short time. The device was programmed to start dissolving after that two-week period. When the researchers examined the mice three weeks after the device was originally implanted, they found that infection had been reduced and only a very faint traces of the implant remained.

This research was important in determining the functionality and biocompatibility of the transient electronic devices. The testing of these devices on animals is also very controversial. Animal testing has been highly opposed by many people and is an issue on the forefront of bioengineering ethics. The researchers were careful to follow Institutional Animal Care and Use Committee protocols throughout their experiments.

4. Applications

Transient electronics devices are still in the beginning stages of development. Although the immediate reaction is positive, there is still much progress to be made.

Medical implants such as pacemakers and defibrillators have helped to revolutionize the medical industry by aiding organs that would otherwise give way to failure. However, current implants are typically designed to last forever, and when the time comes when they are no longer needed, surgery is often necessary to remove them. But what if electronic implants could simply disappear when they were no longer needed? Their development could lead to future medical implants that do not need surgical removal. While the device tested for the paper was designed to degrade passively, the research team has hopes of developing implants that can be wireless triggered in order to dissolve when they are no longer needed. With further development, transient electronics could have a whole range of applications. “Maybe a transient pacemaker, which eventually degrades and disappears,” Rogers said. “We like thermal intervention, but there is also electrical stimulation. It is known that electrical stimulation of bones can stimulate bone growth, so it can be used on fractures to help them heal. Then after the bone is healed, [the implant] naturally disappears.”

Going beyond medical applications, Rogers and his team imagine that this invention could revolutionize the entire electronics industry. By developing electronic devices that naturally degrade into the environment, there is less waste left behind and the environment is less harmed. “We want to exploit the fact that we’re using a silicon based device,” Rogers said. “It allows us to leverage the established electronics industry, and modify existing integrated circuits. They are relatively modest modifications of what’s out there today. Transient electronics can also be used as environmental monitors. For instance, it can be used for tracking oil/chemical spills by dispersing all over the spill. Thereafter, it degrades into compost without any ecological consequences. As more and more gadgets are being launched almost everyday, resulting production of more junk than ever; need for transience in consumer electronics has risen.

5. Conclusion

This is a relatively new technology however transient electronics is definitely a technology worth pursuing. The fact that these devices enhance the quality of life greatly and also have a very minimal environmental impact is very promising for the future development of the technology. While there have been no human trials yet, the component materials of the system are found in implants that have been approved by government regulators for other medical uses. Hence by introducing transience, transient electronics based devices or sub-parts will become compost rather than trash. Furthermore, these devices can very well be used in covert operations where they can simply disappear after serving their purpose. As Roger says, “*Admittedly, we might not be perceiving all the potential uses. We’re still asking new questions*.”

References

[1] http://www.foxnews.com/health/2012/09/27/new-vanishing-electronic-medical-implants-dissolve-inside-body/#ixzz2Xh297Xd2

[2] University of Illinois news

[3] http://www.sciencedaily.com/releases/2013/04/130408122310.htm

[4] K. Bourzac. (2009). “Implantable Silicon Silk Electronics.” MIT Technology

Review. (Website).

http://www.technologyreview.com/news/416104/implantable-silicon-silk-electronics/

[5] (2012). “Smooth as Silk "Transient Electronics" Dissolve in Body or Environment.” TuftsNow. (Website). http://now.tufts.edu/news-releases/smooth-silk-transient-electronics.