Source: *The Straits Times,* pB9
Date: 27 January 2017

Singapore researchers push frontiers of flexible electronics

Tech that can be worn on clothes and skin has potential use in healthcare, defence, robotics

Lin Yangchen

Electronic devices have transformed human society in the last few decades, giving birth to hospital ultrasound machines, manufacturing robots and that smartphone everyone has in their pockets.

Universities here are spearheading the next revolution in electronics, the transition from traditional, hard, bulky circuits to flexible films that people can wear on their clothes and even on their skin.

This could lead to unobtrusive biomedical "plasters" that monitor health indicators like pulse rates round the clock, for instance, or to movement sensors attached to the body for virtual reality gaming.

To get a head start in the field, the National University of Singapore (NUS) is pouring $50 million into a new flexible electronics programme with a 20-year "road map", while Nanyang Technological University (NTU) and the Singapore University of Technology and Design (SUTD) have also started initiatives in the field.

Professor Aaron Thean, who leads the new NUS programme, said flexible electronics would drive the adoption of technology by making it more wearable. "It's a way of integrating electronics into a form which can interact with the human body and with objects much more seamlessly," he said.

He added that while researchers around the world are looking into flexible electronics, NUS has a fresh approach. "Some people look into the materials, some look into the devices and circuits, but we want to do that in the context of new applications. The key is how to bring all these together. Integration is important because if you want to translate technology, you have to put things together," said Prof Thean.

In two decades, he believes, the systems developed by NUS would comprise multiple components stacked together, yet be flexible enough to cling to the skin like stickers.

Professor Nitish Thakor, director of the Singapore Institute for Neurotechnology, one of the institutions taking part in the programme, drew an analogy with living in high-rise buildings. "If everybody lived on the first floor it would take up too much land. If you stack it up, then we can live more compactly. Electronics today is becoming so dense – with billions of transistors on a chip – you cannot keep making the chip bigger and bigger."

At the heart of the NUS programme is a new centre to be finished later this year, to bring researchers from different disciplines together.

One of the projects already under way is an "electronic skin" embedded with tiny pressure sensors that take thousands of measurements a second, which could lead to sophisticated human-like robotic hands that can perform complex tasks. Flexibility is essential here, given the complex movements a real hand is capable of.

Closer to the needs of real humans is a pressure-sensing insole that has been developed for diabetics who have lost the sense of touch in their feet. Flexible sensors filled with a liquid metal alloy transmit pressure data wirelessly to a smartphone app that provides pressure readings in real time as the patient walks around, allowing both doctor and patient to "see the pain" and take preventive action against diabetic foot ulcers that develop due to excessive pressure.

Clinical trials started at Khoo Teck Puat Hospital last October and are expected to take a year. The technology costs only about $300, and provides more data than existing pressure pads that cost thousands of dollars and work only when the patient is standing still, the researchers said.

Over at NTU, flexible electronics research is gathering pace as well, with the new Innovative Centre for Flexible Devices (iFlex) set up earlier this month in collaboration with Stanford University in the United States. The two universities will host joint doctoral and postdoctoral positions.

Professor Chen Xiaodong, director of iFlex, said one focus of the programme is to find simple, scalable and sustainable methods to 3D-print flexible electronics.

But this is no simple matter.The ink used, for instance, must not only conduct electricity, but also be stretchable and stable at temperature extremes.

NTU has also been making electronics stretchable as well as bendable, which are important to allow them to attach to surfaces like skin. Researchers there have managed to make stretchable capacitors – devices that can store and discharge electricity – by giving them a zigzag shape that can shrink and expand like an accordion.

Meanwhile, SUTD's associate provost for research Martin Dunn said that the multidisciplinary nature of the university's research has earned it funding not only from scientific establishments like the National Research Foundation, but also from agencies like the Defence and Education ministries, for a number of research programmes that involve flexible electronics.

One project is a solar-powered textile made of thin wires coated with light-sensitive substances. Project leader Marie Chae Youngjin collaborates with materials scientists, computer scientists and even fashion designers, and gives it a few more years before the textile can be worn on the body and thrown into washing machines. The technology can potentially power devices, from smartphones to flexible cooling clothing and military equipment.

Prof Chen is optimistic about the flexible electronics sector in Singapore. "Singapore's strength in microelectronics gives it a head start in the flexible devices area," he said.

"However, it requires risk-taking to open doors to disruptive technologies never thought possible before."

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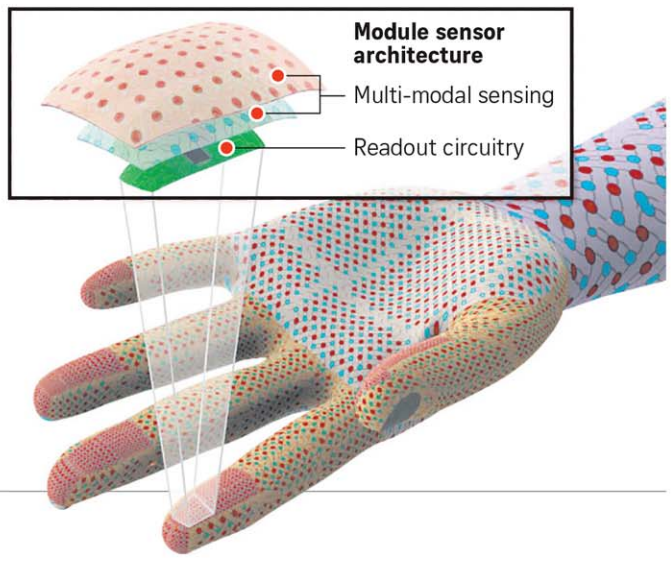
Electronics of the future

Electronics, an essential part of modern society, are set to become even more versatile by being bendable and stretchable. Here is a sneak peek at some of the flexible electronics applications that scientists here are working on to transform every aspect of people's lives.

ELECTRONIC SKIN FOR ROBOTS

NATIONAL UNIVERSITY OF SINGAPORE

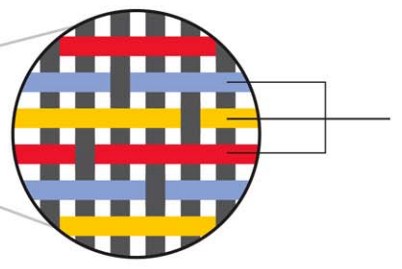
- A glove with thousands of pressure sensors on the surface
- Printed using an inkjet printer with a special ink that conducts electricity
- Sensors collect data at more than 5,000 times a second
- Enables robot to pick up household objects without excessive force



SOLAR-POWERED TEXTILE

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

- Stainless steel wires in a 5-harness satin weave commonly used for closer thread spacing and stability
- Wires are coated with semiconductor material and light-sensitive dyes needed for solar electricity generation
- Wearers can potentially power their smartphones, cooling devices or military equipment



Fibrous electrode: Combination of photo-electrodes with colourful dyes

INSOLE FOR MONITORING FOOT PRESSURE

NATIONAL UNIVERSITY OF SINGAPORE

- Shoe insole fitted with flexible sensors containing a liquid metal alloy of gallium and indium
- Electrical resistance of alloy increases with pressure
- Data is transmitted wirelessly to smartphone which shows pressure changes in real time
- Helps detect excessive pressure that may cause problems like diabetic foot ulcers

Mobile app: Pressure points are colour-coded to show the amount of stress on each point

Sources: NATIONAL UNIVERSITY OF SINGAPORE, SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN ST GRAPHICS: BRYANDT LYN