In the future, you might be able to print electronic devices at home instead of buying them in stores.

Researchers at VIRTUS, IC Design Centre of Excellence have developed a new way to print complex electronic circuits and systems using fully-additive processes. Their unique method is environmentally-friendly, low-cost and scalable compared to subtractive or mixed processes, and produces components with high semiconductor carrier-mobility.

Printed electronics are usually thin, light and flexible, and can be used for, say, intelligent labels that track if milk cartons have been stored in required temperature ranges.

The field is dominated by subtractive-based processes such as laser ablation, where lasers are used to remove material from a solid. These processes, however, require specialised and expensive equipment, use corrosive chemicals and squander material.

Other scientists’ attempts at fully-additive processes, which involve only depositions onto a film, resulted in components with low printed semiconductor carrier-mobility, which would severely limit devices’ speed.

The EEE technique uses widely-available silver paste, which has high electrical and thermal conductivity, for electrodes. The silver electrode is dipped in pentafluorobenzenethiol solution which increases its work function and overcomes the low carrier-mobility problem.

The researchers also used slot die coating to print the semiconductor layer. This results in fewer crystal grain boundaries, which quickens electrons’ flow, further increasing devices’ speed.

The technique can print passive elements including capacitors, resistors, inductors and two metal-interconnect layers – to date, the only fully-additive process that can realise complex circuits and systems on flexible plastic films. To demonstrate its commercial viability, the researchers printed one proposed and two conventional differential amplifiers, and a 4-bit digital-to-analog converter.

The team also developed a comprehensive printed transistor model that is simple, accurate and compatible with industry-standard integrated circuit electronic design automation tools. This model allows manufacturers to simulate potential printed transistors’ operation, which is crucial for to design practical printed electronic circuits.

The researchers showed that, by using an appropriate layout, the mismatch between printed transistors can be reduced to a relatively low 8%, despite variations of up to almost 40% between individual transistors.

Dr Ge Tong, a senior research fellow at EEE, said: “What manufacturers get from the simulator will be very close to what they get if they print the actual circuit.”
Fall sick in the future and you could get medicine tailored to your DNA.

Professor Yu Hao and his team have developed a more accurate and low-cost way to sequence a person’s DNA at high resolution, which will enable more personalised medicine.

Their technique relies on optical and chemical methods to identify DNA’s different nucleotide bases – essentially the building blocks of DNA.

Currently, DNA sequencing is mostly done through optical or chemical methods. The optical method involves tagging DNA samples with chemicals that cause different nucleotide bases to give off different levels of fluorescence.

The machines that carry out this work, however, are very large and cost about US$10 million (S$14.3 million) each.

During the chemical method, DNA molecules are attached to microbeads, which are then distributed into wells on the surface of a chip. The wells are then flooded sequentially with each of the four A, T, C and G nucleotides. Whenever the DNA on the microbead incorporates the nucleotide, it releases hydrogen ions. Sensors read the changes in each well’s power of hydrogen, or pH, value to identify the DNA’s nucleotide bases.

The machines used in the chemical method, however, cannot tell whether a microbead was deposited into a well. Even if a well is accidentally empty, the machine will still report a pH value for it due to unwanted signals from neighbouring wells, causing inaccuracies in the DNA sequencing.

The EEE researchers’ sequencer uses the chemical method, but adds a photodiode which looks for shadows cast by the microbead in each well under a white light source. If there is no shadow – and hence no microbead – the sequencer does not report a pH value for that well.

The EEE technology is also more accurate and able to determine pH values down to 0.01 pH resolution, compared to the traditional chemical method’s 0.1 pH resolution.

Professor Yu Hao from EEE added that the sequencer, which is a 1cm-by-1cm integrated circuit chip, costs just a few hundred dollars each. He said: “This will be a boon to cancer patients and people fighting other diseases.”