Brain process takes paper shape

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A paper-based device that mimics the electrochemical signalling in the human brain has been created by a group of researchers from China.

The thin-film transistor (TFT) has been designed to replicate the junction between two neurons, known as a biological synapse, and could become a key component in the development of artificial neural networks, which could be utilised in a range of fields from robotics to computer processing.

The TFT, which has been presented today in the journal *Nanotechnology*, is the latest device to be fabricated on paper, making the electronics more flexible, cheaper to produce and environmentally friendly.

The artificial synaptic TFT consisted of indium zinc oxide (IZO), as both a channel and a gate electrode, separated by a 550-nanometre-thick film of nanogranular silicon dioxide electrolyte, which was fabricated using a process known as chemical vapour deposition.

The design was specific to that of a biological synapse—a small gap that exists between adjoining neurons over which chemical and electrical signals are passed. It is through these synapses that neurons are able to pass signals and messages around the brain.

All neurons are electrically excitable, and can generate a 'spike' when the neuron's voltage changes by large enough amounts. These spikes cause signals to flow through the neurons which cause the first neuron to release chemicals, known as neurotransmitters, across the synapse, which

are then received by the second neuron, passing the signal on.

Similar to these output spikes, the researchers applied a small voltage to the first electrode in their device which caused protons—acting as a neurotransmitter—from the silicon dioxide films to migrate towards the IZO channel opposite it.

As protons are positively charged, this caused negatively charged electrons to be attracted towards them in the IZO channel which subsequently allowed a current to flow through the channel, mimicking the passing on of a signal in a normal neuron.

As more and more neurotransmitters are passed across a synapse between two neurons in the brain, the connection between the two neurons becomes stronger and this forms the basis of how we learn and memorise things.

This phenomenon, known as synaptic plasticity, was demonstrated by the researchers in their own device. They found that when two short voltages were applied to the device in a short space of time, the second voltage was able to trigger a larger current in the IZO channel compared to the first applied voltage, as if it had 'remembered' the response from the first voltage.

Corresponding author of the study, Qing Wan, from the School of Electronic Science and Engineering, Nanjing University, said: 'A paper-based synapse could be used to build lightweight and biologically friendly artificial neural networks, and, at the same time, with the advantages of flexibility and biocompatibility, could be used to create the perfect organism–machine interface for many biological applications.'

More information: 'Low-voltage protonic/electronic hybrid indium

zinc oxide synaptic transistors on paper substrates' Guodong Wu et al 2014 *Nanotechnology* 25 094001, iopscience.iop.org/0957-4484/25/9/094001/article

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