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Biotronics branches out

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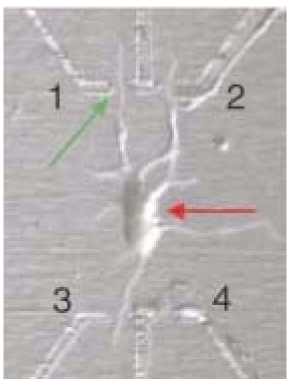
Harvard researchers have developed nanowire transistors that interface with individual neurons and, even better, with the individual neuronal extensions that reach out to contact other cells.

Researchers led by Charles Lieber, professor of chemistry at Harvard University, Cambridge, US, created arrays of silicon nanowire transistors that could resist corrosion during the extended incubation times needed for cell culture (up to 10 days at 37 degrees Celsius). The researchers patterned polylysine films onto the surface where the cells were grown in order to determine where they would spread.

Cultured neurons were given about a week to spread their axons and dendrites along the pre-defined paths that led towards the nanowire transistors.

The researchers applied this approach in a range of different geometries, and consistently obtained a high percentage (over 80 per cent) of active contacts between the nanowires and the dendrites and axons. In one experiment, a single neuron was made to run its axon past an array of 50 transistors lined up at 10μm intervals, 43 of which established functional contacts.



Optical image of a cortex neuron connected to three of the four functional nanowire devices in the array (labelled 1, 2, 3 and 4). Two possible stimulation approaches are indicated: intracellular stimulation (red arrow in soma) and extracellular nanowire-based stimulation (green arrow on nanowire 1). © Science

So the electronic devices ended up on the same length scale as the natural connections between nerve cells, which are called synapses. 'The ultra-small nanowire transistors enable us for the first time to create artificial synapses to the individual axon and dendrite projections of neurons that interconnect and carry information in our brains,' Lieber told Chemistry World. Such arrangements will let researchers study and manipulate the electrical behaviour of individual nerve cells in unprecedented detail and with minimal disturbance.

The age of biotronics, where electronic devices can directly and easily be interfaced with living organisms, was launched when researchers began contacting neurons to electronic devices (*Chemistry World*, September 2004, p30).

William Ditto, a biomedical engineer at the University of Florida, US, says Lieber's work is a major breakthrough. 'Until recently, we have been like elephants trying to tickle a flea … the startling improvements this technology makes in our ability to understand how individual neurons work may well be dwarfed by the impact it will have upon the emerging field of brain–machine interfaces and the construction of hybrid living/silicon computational devices,' Ditto told Chemistry World.

Cees Dekker, who develops nanotube transistors at the Technical University of Delft, the Netherlands, agrees. 'This work from the Lieber group will allow us to study axon propagation at a scale that was not possible before,' said Dekker. 'Nanowires and nanotubes do allow to probe cells at a near-molecular scale and I am convinced that this will yield new insights."

Michael Gross

References

F Patolsky *et al*, *Science*, 2006, **313**, 1100

Plugging brains into computers
With neurons being grown on silicon chips, Michael Gross investigates the possibility of direct