Published:
August 24, 2006

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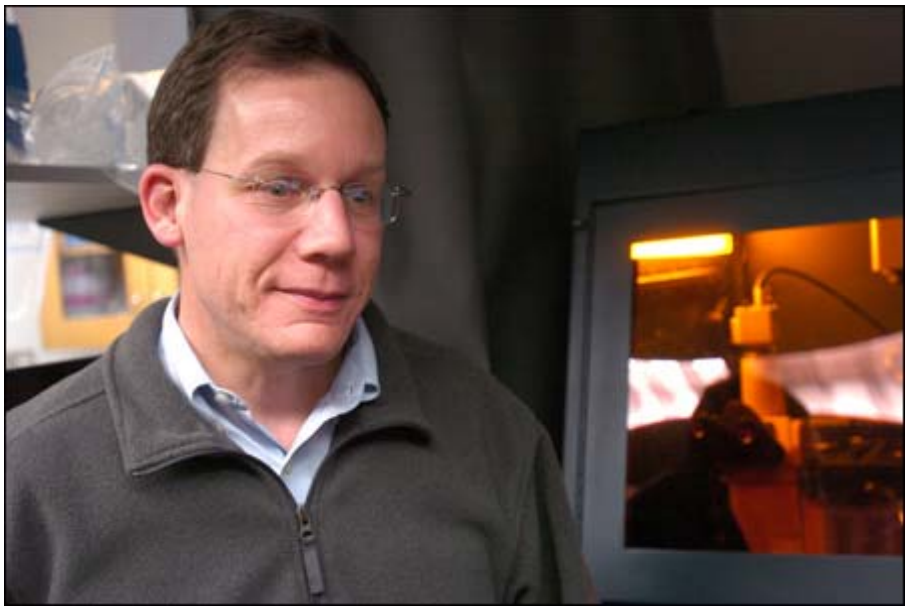

Harvard chemist Charles M. Lieber and colleagues report on this marriage of nanowires and neurons in the journal Science. (Staff photo Kris Snibbe/Harvard News Office)

Nanowire arrays can detect signals along individual neurons

Merger of nanowires and neurons could boost efforts to measure and understand brain activity

By Steve Bradt
FAS Communications

Opening a whole new interface between nanotechnology and neuroscience, scientists at Harvard University have used slender silicon nanowires to detect, stimulate, and inhibit nerve signals along the axons and dendrites of live mammalian neurons.

Harvard chemist Charles M. Lieber and colleagues report on this marriage of nanowires and neurons this week in the journal Science.

"We describe the first artificial synapses between nanoelectronic devices and individual mammalian neurons, and also the first linking of a solid-state device -- a nanowire transistor -- to the neuronal projections that interconnect and carry information in the brain," says Lieber, the Mark Hyman Jr. Professor of Chemistry in Harvard's Faculty of Arts and Sciences and Division of Engineering and Applied Sciences. "These extremely local devices can detect, stimulate, and inhibit propagation of neuronal signals with a spatial resolution unmatched by existing techniques."

Electrophysiological measurements of brain activity play an important role in understanding signal propagation through individual neurons and neuronal networks, but existing technologies are relatively crude: Micropipette electrodes poked into cells are invasive and harmful, and microfabricated electrode arrays are too bulky to detect activity

at the level of individual axons and dendrites, the neuronal projections responsible for electrical signal propagation and interneuron communication.

By contrast, the tiny nanowire transistors developed by Lieber and colleagues gently touch a neuronal projection to form a hybrid synapse, making them noninvasive, and are thousands of times smaller than the electronics now used to measure brain activity.

Lieber's group has previously shown that nanowires can detect, with great precision, molecular markers indicating the presence of cancer in the body, as well as single viruses. The group's latest work takes advantage of the size similarities between ultra-fine silicon nanowires and the axons and dendrites projecting from nerve cells: Nanowires, like neuronal offshoots, are just tens of nanometers in width, making the thin filaments a good match for intercepting nerve signals.

Because the nanowires are so slight -- their contact with a neuron is no more than 20 millionths of a meter in length -- Lieber and colleagues were able to measure and manipulate electrical conductance at as many as 50 locations along a single axon.

The current work involves measurement of signals only within single mammalian neurons; the researchers are now working toward monitoring signaling among larger networks of nerve cells. Lieber says the devices could also eventually be configured to measure or detect neurotransmitters, the chemicals that leap synapses to carry electrical impulses from one neuron to another.

"This work could have a revolutionary impact on science and technology," Lieber says. "It provides a powerful new approach for neuroscience to study and manipulate signal propagation in neuronal networks ata level unmatched by other techniques; it provides a new paradigm for building sophisticated interfaces between the brain and external neural prosthetics; it represents a new, powerful, and flexible approach for real-time cellular assays useful for drug discovery and other applications; and it opens the possibility for hybrid circuits that couple the strengths of digital nanoelectronic and biological computing components."

Lieber's co-authors on the Science paper are Fernando Patolsky, Brian P. Timko, Guihua Yu, Ying Fang, Andrew B. Greytak, and Gengfeng Zheng, all of Harvard's Department of Chemistry and Chemical Biology. Their work was supported by the Defense Advanced Research Projects Agency and Applied Biosystems.

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