Nano World: Superior nanowire transistors

Transistors made with semiconductor wires just nanometers or billionths of a meter wide can exceed the performance of current state-of-the-art silicon transistors by three or four times, experts tell UPI's Nano World.

Moreover, the nanowire devices show "more attractive scaling in performance as they are made smaller," said researcher Charles Lieber, a chemist at Harvard University in Cambridge, Mass. "This shows clearly that there is a reason, not simply hype, to consider developing nanowire devices for electronic applications with the expectation that their performance can exceed the best possible in industry."

Specific applications for nanowire transistors in future "include use in building high-performance logic circuits as well as host of electronics applications on unconventional substrates, such as plastics, where such high-performance devices have not been possible," Lieber added.

Modern computers work by symbolizing data as a series of ones and zeros, binary digits known as bits. This code is most often conveyed in electronic devices via field-effect transistors or FETs, which use voltage to control the flow of current between two terminals, behaving like switches that can either be flicked one way or the other to represent a one or a zero.

Lieber and his colleagues manufactured transistors made with 15-nanometer-thick wires possessing cores of germanium and shells of silicon. "It is a tour de force of materials growth control and interface engineering to create these structures," said physicist Curt Richter, leader of the nanoelectronic device metrology project at the National Institute of Standards and Technology in Gaithersburg, Md.

Their performance not only exceeded that of the best silicon MOSFETs but is also the highest seen in nanowire FETs so far. Lieber and his colleagues presented their findings in the March 25 issue of the British scientific journal *Nature*.

"It's very exciting to see the performance of these transistors. They're so good, better than any silicon devices," materials scientist Yu Cui at Stanford University in California said. "I think a lot of people will be going into this area, especially in the electrical engineering and materials science fields."

Semiconductors are often made with ingredients known as dopants. These help generate particles that carry electric charge. The nanowires the researchers created can instead generate charge carriers without the need for dopants. Instead, the germanium cores interact with their silicon shells to create charge carriers. Without dopants to serve as obstructions, electrons can apparently whiz inside the nanowires Lieber and his colleagues made nearly ballistically, without the kind of scattering that can degrade performance in conventional devices.

While the nanowire transistors Lieber and his colleagues demonstrated are comparable to but slightly worse in performance to the best ones made with carbon nanotubes, theirs can be made with reproducible electronic characteristics "unlike carbon nanotube FETs, and this is absolutely essential for moving beyond single nanowire or nanotube devices," he said.

When considering the high degree of controllability in the electronic structure of these nanowire transistors, "it simply exceeds carbon nanotube FETs in many ways," said Zhong Lin Wang, a materials scientist in nanotechnology in the Georgia Institute of Technology in Atlanta. "This research will inspire a whole field in nanowire-based nanoelectronics and it lights up the road of nanoelectronics based on bottom-up approach."

Future research could push the performance of the germanium-silicon nanowires further, as well as scale them "to ever smaller sizes," Lieber said. His team is also investigating other materials for use in nanowire devices.

"Both nanowire and nanotube FETs have a long way to go before they can be manufactured at the current scale of silicon MOSFETs," Lieber cautioned. Additional challenges include building and interconnecting these devices on a large scale.