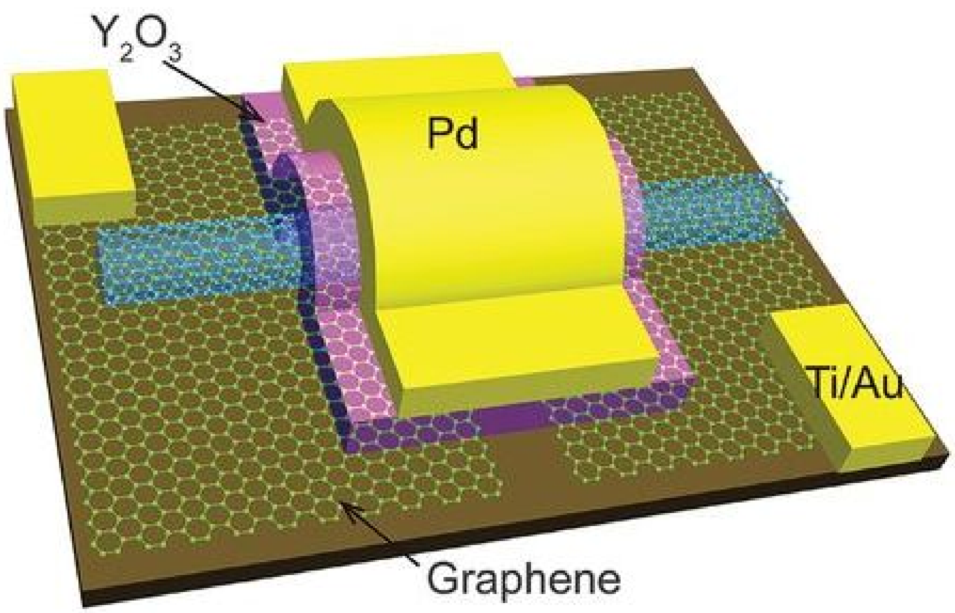
Researchers build carbon nanotube transistors that outperform those made with silicon

January 20 2017, by Bob Yirka



Schematic diagram showing the structure of a GC CNT FET. Credit: (c) *Science* (2017). DOI: 10.1126/science.aaj1628

(Phys.org)—A team of researchers at Peking University has built a carbon nanotube-based working transistor and report that it outperformed larger transistors made with silicon. In their paper published in the journal *Science*, the team describes how they built the transistor, how it performed and the challenges that still remain before such transistors can be mass produced.

Everyone in the computer business knows the limit to which silicon-based transistors can be made smaller is drawing ever closer, so many teams around the world are searching for a suitable replacement. One of the most promising candidates is carbon nanotubes—due to their unique properties, transistors based on them could be smaller, faster and more efficient. Unfortunately, the difficulty in growing carbon nanotubes and their sometimes persnickety nature means that a way to make them and mass produce them has not been found. In this new effort, the researchers report on a method of creating carbon nanotube transistors that are suitable for testing, but not mass production.

To create the transistors, the researchers took a novel approach—instead of growing carbon nanotubes that had certain desired properties, they grew some and put them randomly on a silicon surface and then added electronics that would work with the properties they had—clearly not a strategy that would work for mass production, but one that allowed for building a carbon nanotube transistor that could be tested to see if it would verify theories about its performance. Realizing there would still be scaling problems using traditional electrodes, the researchers built a new kind by etching very tiny sheets of graphene. The result was a very tiny transistor, the team reports, capable of moving more current than a standard CMOS transistor using just half of the normal amount of voltage. It was also faster due to a much shorter switch delay, courtesy of the intrinsic delay of just 70 femtoseconds.

The work done by the team in China is important because it offers physical evidence that money being spent on research into carbon nanotubes as a viable replacement for silicon will indeed pay off if a way to mass produce them can be found.

More information: Chenguang Qiu et al. Scaling carbon nanotube complementary transistors to 5-nm gate lengths, *Science* (2017). DOI: 10.1126/science.aaj1628

Abstract

High-performance top-gated carbon nanotube field-effect transistors (CNT FETs) with a gate length of 5 nanometers can be fabricated that perform better than silicon complementary metal-oxide semiconductor (CMOS) FETs at the same scale. A scaling trend study revealed that the scaled CNT-based devices, which use graphene contacts, can operate much faster and at much lower supply voltage (0.4 versus 0.7 volts) and with much smaller subthreshold slope (typically 73 millivolts per decade). The 5-nanometer CNT FETs approached the quantum limit of FETs by using only one electron per switching operation. In addition, the contact length of the CNT CMOS devices was also scaled down to 25 nanometers, and a CMOS inverter with a total pitch size of 240 nanometers was also demonstrated.