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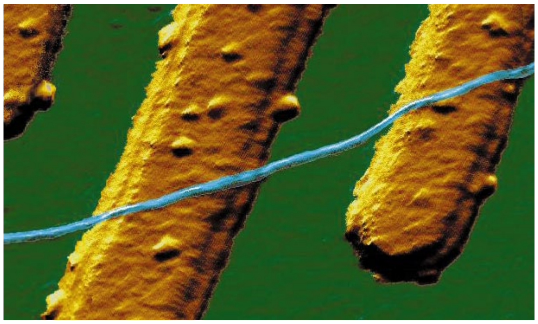
Basing transistors on lone carbon nanotubes



Dekker et al.

False-color atomic force microscope image of a carbon nanotube (blue) lying in contact with two metal electrodes on a silicon base coated with a layer of silicon dioxide.

Using individual molecules as transistors promises to advance miniaturization strategy in the electronics and computer industries. Fabricating such tiny components, however, presents numerous challenges.

Now, researchers have shown that a microscopic tube of carbon atoms lying across a pair of metal electrodes can operate as a simple transistor at room temperature. Cees Dekker and his coworkers at the Delft University of Technology in the Netherlands describe their device in the May 7 NATURE.

The fabrication of this nanotube transistor represents "a new, important step towards molecular electronics," Dekker says.

Carbon nanotubes are cylindrical molecules about 1 nanometer in diameter and 1 to 100 micrometers long. They can be thought of as rolled-up sheets of carbon atoms arranged in a hexagonal network. Depending on the diameter of the tube and the alignment of the hexagonal pattern along the cylinder's axis, a nanotube can either conduct electricity like a metal or behave as a semiconductor.

The Delft team deposited carbon nanotubes onto arrays of prefabricated nanoelectrodes on the surface of a silicon dioxide layer covering a silicon base. The researchers then looked for semiconducting nanotubes lying across a pair of electrodes. By applying a voltage to the silicon base, they could switch such a nanotube from a conducting to a nonconducting state.

Because the device operates at room temperature, it meets an important requirement for potential practical applications, Dekker notes. Moreover, he adds, these nanotube transistors are generally quite robust, surviving a large number of experimental tests over a period of months.

"Nanotubes have the advantage [over other unimolecular devices] of being much sturdier," says Robert M. Metzger of the University of Alabama in Tuscaloosa, who leads a group that developed a molecular rectifier (SN: 11/8/97, p. 293). However, subtle differences in the structure of individual nanotubes make it hard to predict a given nanotube's electronic properties.

Dekker and his coworkers are now trying to improve their control over the nanotube deposition process. They are also seeking ways to increase the transistor's output for a given input voltage.

"This is fascinating physics," Dekker says. Using single molecules as active electronic components, however, is a new research area, he warns. "Don't expect a molecular computer within a few years."

—I. Peterson