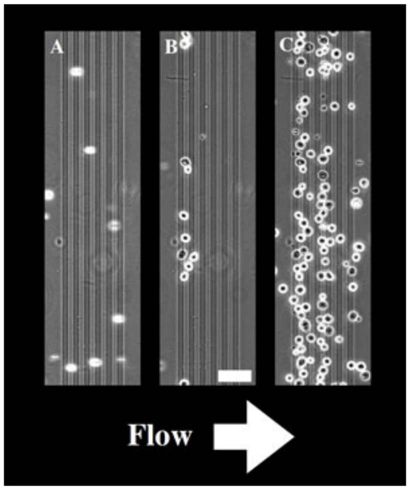
Their method, which involves innovations upon conventional cell-capture techniques, has already proved effective in creating arrays of human liver cells and mouse pluripotent cells—which, similar to stem cells, can develop into more than one cell type.

"The technique could prove valuable for learning about how cells communicate and differentiate," says NIST chemist Darwin Reyes. "We think this method could provide an effective way to selectively induce cells to differentiate and watch their behavior as they develop."

Adherent cells need to be attached to a surface to survive, and one common way of getting them there is by using a technique called dielectrophoresis (DEP), which Reyes says is not necessarily the best for cells' health. A batch of cells is placed into a fluid medium that has low electrical conductivity—sucrose in water, for example—and then subjected to an electric field that attracts the cells to a nearby surface. But the DEP process requires the cells to spend between 20 and 30 minutes in the medium, which appears to cause problems when the cells are trying to attach to the surface.

"Cells typically die rather soon after that much time exposed to the sucrose, since they cannot attach to the surface," Reyes says. "It's tough to run useful experiments if you only have a short window of opportunity."



(A) As cells flow down the channel, they pass over the electrodes (vertical dark gray lines) until (B) the electrodes are activated and the cells are trapped and anchored. (C) The cells remain adhered even while being exposed continuously to a fluid flow. Scale bar 50 micrometers.

Credit: NIST
View hi-resolution image

The team experimented with different materials before finding that they could use a layer of substance called polyelectrolyte that has its own positive electric charge, which attracts the cells quickly. Before depositing this material, they laid down a thin layer of natural protein called fibronectin that helps cells to survive once they stick. With this new hybrid surface, the cells need spend only about four minutes in the fluid before they are returned to a more nurturing medium that helps them grow and attach better. As a result, the cells can survive on the surface for a week or more.

Because of their success in creating arrays of neural cells, the team has recently started to pattern liver cells as well. Combining liver cells with this technique could be useful in toxicology studies, Reyes suggests. "The liver is made up of several types of cells that work together," he says. "Creating arrays of them with certain cells positioned in particular locations could help us study how each of them might contribute to the overall process of filtering out a toxin from the bloodstream."

* D.R. Reyes, J.S. Hong, J.T. Elliott and M. Gaitan. Hybrid cell adhesive material for instant dielectrophoretic cell trapping and long-term cell function assessment. *Langmuir*, 2011, 27, 10027-10034, DOI: 10.1021/la200762j.

Media Contact: Chad Boutin, boutin@nist.gov, 301-975-4261

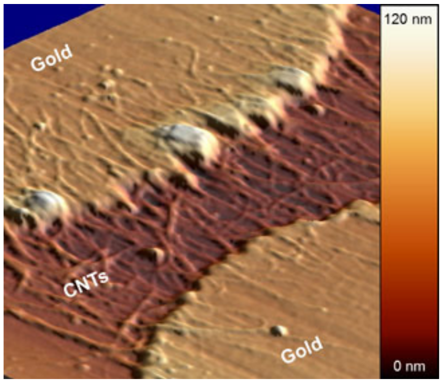
Comment on this article. back to top

NIST Uncovers Reliability Issues for Carbon Nanotubes in Future Electronics

Carbon nanotubes offer big promise in a small package. For instance, these tiny cylinders of carbon molecules theoretically can carry 1,000 times more electric current than a metal conductor of the same size. It's easy to imagine carbon nanotubes replacing copper wiring in future nanoscale electronics.

But—not so fast. Recent tests at the National Institute of Standards and Technology (NIST) suggest device reliability is a major issue.

Copper wires transport power and other signals among all the parts of integrated circuits; even one failed conductor can cause chip failure. As a rough comparison, NIST researchers fabricated and tested numerous nanotube interconnects between metal electrodes. NIST test results, described at a conference this week,* show that nanotubes can sustain extremely high current densities (tens to hundreds of times larger than that in a typical semiconductor circuit) for several hours but slowly degrade under constant current. Of greater concern, the metal electrodes fail—the edges recede and clump—when currents rise above a certain threshold. The circuits failed in about 40 hours.



Micrograph of recession and clumping in gold electrodes after NIST researchers applied 1.7 volts of electricity to the carbon nanotube wiring for an hour. The NIST reliability tests may help determine whether nanotubes can replace copper wiring in next-generation electronics.

Credit: M. Strus/NIST

View hi-resolution image

While many researchers around the world are studying nanotube fabrication and properties, the NIST work offers an early look at how these materials may behave in real electronic devices over the long term. To support industrial applications of these novel materials, NIST is developing measurement and test techniques and studying a variety of nanotube structures, zeroing in on what happens at the intersections of nanotubes and metals and between different nanotubes. "The common link is that we really need to study the interfaces," says Mark Strus, a NIST postdoctoral researcher.

In another, related study published recently,** NIST researchers identified failures in carbon nanotube networks—materials in which electrons physically hop from tube to tube. Failures in this case seemed to occur between nanotubes, the point of highest resistance, Strus says. By monitoring the starting resistance and initial stages of material degradation, researchers could predict whether resistance would degrade gradually—allowing operational limits to be set—or in a sporadic, unpredictable way that would undermine device performance. NIST developed electrical stress tests that link initial resistance to degradation rate, predictability of failure and total device lifetime. The test can be used to screen for proper fabrication and reliability of nanotube networks.

Despite the reliability concerns, Strus imagines that carbon nanotube networks may ultimately be very useful for some electronic applications. "For instance, carbon nanotube networks may not be the replacement for copper in logic or memory devices, but they may turn out to be interconnects for flexible electronic displays or photovoltaics," Strus says.

Overall, the NIST research will help qualify nanotube materials for next-generation electronics, and help process developers determine how well a structure may tolerate high electric current and adjust processing accordingly to optimize both performance and reliability.

* M.C. Strus, R.R. Keller and N. Barbosa III. Electrical reliability and breakdown mechanisms in single-walled carbon nanotubes. Paper presented at IEEE Nano 2011, Portland, Ore., Aug. 17, 2011.

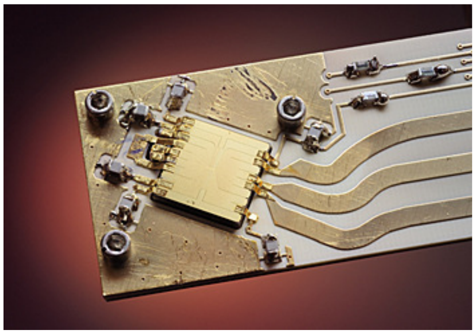
** M.C. Strus, A.N. Chiaramonti, Y.L. Kim, Y.J. Jung and R.R. Keller. Accelerated reliability testing of highly aligned single-walled carbon nanotube networks subjected to dc electrical stressing. *Nanotechnology* 22 pp. 265713 (2011).

Media Contact: Laura Ost, laura.ost@nist.gov, 303-497-4880

Comment on this article. back to top

NIST Demonstrates First Quantum 'Entanglement' of Ions Using Microwaves

Physicists at the National Institute of Standards and Technology (NIST) have, for the first time, linked the quantum properties of two separated ions (electrically charged atoms) by manipulating them with microwaves instead of the usual laser beams. The feat raises the possibility of replacing today's complex, room-sized quantum computing "laser parks" with miniaturized, commercial microwave technology similar to that used in smart phones.



Gold ion trap on aluminum nitride backing. In NIST microwave quantum computing experiments, two ions hover above the middle of the square gold trap, which measures 7.4 millimeters on a side. Scientists manipulate and entangle the ions using microwaves fed into wires on the trap from the three thick electrodes at the lower right.

Credit: Y. Colombe/NIST

View hi-resolution bottom image

Microwaves have been used in past experiments to manipulate single ions, but the NIST group is the first to position microwaves sources close enough to the ions—just 30 micrometers away—and create the conditions enabling entanglement, a quantum phenomenon expected to be crucial for transporting information and correcting errors in quantum computers.

Described in the August 11, 2011, issue of *Nature*,* the experiments integrate wiring for microwave sources directly on a chip-sized ion trap and use a desktop-scale table of lasers, mirrors and lenses that is only about one-tenth of the size previously required. Low-power ultraviolet lasers still are needed to cool the ions and observe experimental results but might eventually be made as small as those in portable DVD players. Compared to complex, expensive laser sources, microwave components could be expanded and upgraded more easily to build practical systems of thousands of ions for quantum computing and simulations.

"It's conceivable a modest-sized quantum computer could eventually look like a smart phone combined with a laser pointer-like device, while sophisticated machines might have an overall footprint comparable to a regular desktop PC," says NIST physicist Dietrich Leibfried, a co-author of the new paper.

Quantum computers would harness the unusual rules of quantum physics to solve certain problems—such as breaking today's most widely used data encryption codes—that are currently intractable even with supercomputers. A nearer-term goal is to design quantum simulations of important scientific problems, to