Nano World: Carbon nanotube capacitors

February 3 2006

Carbon nanotubes could help release and hold electrical energy, for potential use in everything from microchips to hybrid cars, experts told UPI's Nano World.

The nanotube devices are known as capacitors. While a battery stores compounds known as electrochemicals, a capacitor is made of a pair of electrodes separated by an insulator that each stores an opposite charge. Batteries release energy by reacting electrochemicals together, while capacitors do so when they are hooked into circuits. While capacitors might not be capable of storing as much energy as batteries of the same size, they could be much better at delivering more energy over a short time, explained researcher Gehan Amaratunga, an electronic engineer at Cambridge University in Britain.

Amaratunga and his colleagues have developed nanoscale capacitors made from multi-walled carbon tubes roughly 70 nanometers or billionths of a meter wide. These nanotubes were grown vertically from nickel catalyst dots on niobium films. The scientists went on to cover this nanotube forest and its niobium floor with a silicon-nitride layer and then an aluminum film. The resulting capacitor is made from niobium and aluminum electrodes separated by an insulating silicon-nitride layer and carbon nanotubes.

The nanotubes dramatically boost the amount of surface, and thus electrical charge, that each metal electrode can possess. The potential for smaller and more powerful capacitors might prove crucial in developing microchips with ever denser circuitry, Amaratunga said, which need high power "in the minimum area possible." Developing the kind of nanoscale capacitors needed for such ultra-dense circuitry has until now proven very complicated or unreliable.

Moreover, such nanoscale capacitors might help improve the development of compact and cost effective supercapacitors, which has direct bearing on "electric or hybrid electric vehicles such as the Toyota Prius," Amaratunga said. These supercapacitors could help reduce the amount of battery weight these vehicles carry, thus improving their fuel consumption or performance or both, he explained.

The researchers are currently pursuing supercapacitors for portable electronics "such as PDAs, where the optimization of battery weight and lifetime remains a significant issue," Amaratunga added. He and his colleagues published their findings in the journal Applied Physics Letters.

The nanoscale capacitors might also serve in advanced memory chips, said Manish Chhowalla, a materials scientist at Rutgers University in Piscataway, N.J., who did not participate in this study. He noted that nanocapacitor conductance was high when they stored charge and low when they did not, which could serve as the equivalent of zeroes and ones "that are the basis of any memory device." The advantage nanotube capacitors might have over competing memory storage methods is the fact that they take up most of their space vertically, allowing more of them to be packed together onto a surface.

In the future, Amaratunga hopes to move away from electron beam lithography, their current method of placing the nickel catalyst dots on the niobium films, to other techniques more viable for larger surfaces. He anticipated it would take six to eight years before their nanoscale capacitors are use in products. Their work is sponsored by Samsung, who "will guide the commercialization of the research," Amaratunga said.