Nanoscientists fired up about battery alternative

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Just about everything that runs on batteries - flashlights, cell phones, electric cars, missile-guidance systems - would be improved with a better energy supply. But traditional batteries haven't progressed far beyond the basic design developed by Alessandro Volta in the 19th century. Until now.

Work at MIT's Laboratory for Electromagnetic and Electronic Systems (LEES) holds out the promise of the first technologically significant and economically viable alternative to conventional batteries in more than 200 years.

Joel E. Schindall, the Bernard Gordon Professor of Electrical Engineering and Computer Science (EECS) and associate director of the Laboratory for Electromagnetic and Electronic Systems; John G. Kassakian, EECS professor and director of LEES; and Ph.D. candidate Riccardo Signorelli are using nanotube structures to improve on an energy storage device called an ultracapacitor.

Capacitors store energy as an electrical field, making them more efficient than standard batteries, which get their energy from chemical reactions. Ultracapacitors are capacitor-based storage cells that provide quick, massive bursts of instant energy. They are sometimes used in fuel-cell vehicles to provide an extra burst for accelerating into traffic and climbing hills.

However, ultracapacitors need to be much larger than batteries to hold the same charge.

The LEES invention would increase the storage capacity of existing commercial ultracapacitors by storing electrical fields at the atomic level.

Although ultracapacitors have been around since the 1960s, they are relatively expensive and only recently began being manufactured in sufficient quantities to become cost-competitive. Today you can find ultracapacitors in a range of electronic devices, from computers to cars.

However, despite their inherent advantages - a 10-year-plus lifetime, indifference to temperature change, high immunity to shock and vibration and high charging and discharging efficiency - physical constraints on electrode surface area and spacing have limited ultracapacitors to an energy storage capacity around 25 times less than a similarly sized lithium-ion battery.

The LEES ultracapacitor has the capacity to overcome this energy limitation by using vertically aligned, single-wall carbon nanotubes - one thirty-thousandth the diameter of a human hair and 100,000 times as long as they are wide. How does it work? Storage capacity in an ultracapacitor is proportional to the surface area of the electrodes. Today's ultracapacitors use electrodes made of activated carbon, which is extremely porous and therefore has a very large surface area. However, the pores in the carbon are irregular in size and shape, which reduces efficiency. The vertically aligned nanotubes in the LEES ultracapacitor have a regular shape, and a size that is only several atomic diameters in width. The result is a significantly more effective surface area, which equates to significantly increased storage capacity.

The new nanotube-enhanced ultracapacitors could be made in any of the sizes currently available and be produced using conventional technology.

"This configuration has the potential to maintain and even improve the high performance characteristics of ultracapacitors while providing energy storage densities comparable to batteries," Schindall said. "Nanotube-enhanced ultracapacitors would combine the long life and high power characteristics of a commercial ultracapacitor with the higher energy storage density normally available only from a chemical battery."

This work was presented at the 15th International Seminar on Double Layer Capacitors and Hybrid Energy Storage Devices in Deerfield Beach, Fla., in December 2005.

Source: MIT

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