International Research Team Develops Ultrahigh-power Energy Storage Devices

(Drexel University [1]) -

A team of researchers from the U.S. and France report the development of a micro-supercapacitor with remarkable properties. These micro-supercapacitors have the potential to power nomad electronics, wireless sensor networks, biomedical implants, active radiofrequency identification (RFID) tags and embedded microsensors, among other devices.

Supercapacitors, also called electric double layer capacitors (EDLCs) or ultracapacitors, bridge the gap between batteries, which offer high energy densities but are slow, and “conventional” electrolytic capacitors, which are fast but have low energy densities.

The newly developed devices described in Nature Nanotechnology have powers per volume that are comparable to electrolytic capacitors, capacitances that are four orders of magnitude higher, and energies per volume that are an order of magnitude higher. They were also found to be three orders of magnitude faster than conventional supercapacitors, which are used in backup power supplies, wind power generators and other machinery. These new devices have been dubbed “micro-supercapacitors” because they are only a few micrometers (0.000001 meters) thick.

What makes this possible? “Supercapacitors store energy in layers of ions at high surface area electrodes,” said Dr. Yury Gogotsi, Trustee Chair Professor of materials science and engineering at Drexel University, and a co-author of the paper. “The higher the surface area per volume of the electrode material, the better the performance of the supercapacitor."

Vadym Mochalin, research assistant professor of materials science and engineering at Drexel and co-author, said, "We use electrodes made of onion-like carbon, a material in which each individual particle is made up of concentric spheres of carbon atoms, similar to the layers of an onion. Each particle is 6-7 nanometers in diameter."

This is the first time a material with very small spherical particles has been studied for this purpose. Previously investigated materials include activated carbon, nanotubes, and carbide-derived carbon (CDC).

"The surface of the onion-like carbons is fully accessible to ions, whereas with some other materials, the size or shape of the pores or of the particles themselves would slow down the charging or discharging process," Mochalin said. "Furthermore, we used a process to assemble the devices that did not require a polymer binder material to hold the electrodes together, which further improved the electrode conductivity and the charge/discharge rate. Therefore, our supercapacitors can deliver power in milliseconds, much faster than any battery or supercapacitor used today."

The Drexel team of Gogotsi and Mochalin collaborated with Dr. David Pech, Dr. Magali Brunet, Hugo Durou, Peihua Huang, Dr. Pierre-Louis Taberna, and professor Patrice Simon, all working in Toulouse, France, on the Nature Nanotechnology paper. A grant from the Partner University Fund of the French-American Cultural Exchange allowed two of the Toulouse-based researchers, Pech and Huang, to spend a month each visiting Professor Gogotsi's laboratory at Drexel University in Philadelphia. Additional exchange visits are planned for the 2010-2011 academic year. The effort at Drexel University is based upon work supported as part of the Fluid Interface Reactions, Structures and Transport (FIRST) Center, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under award no. ERKCC61.

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