# Flexible, transparent supercapacitors -- bend and twist them like a poker card

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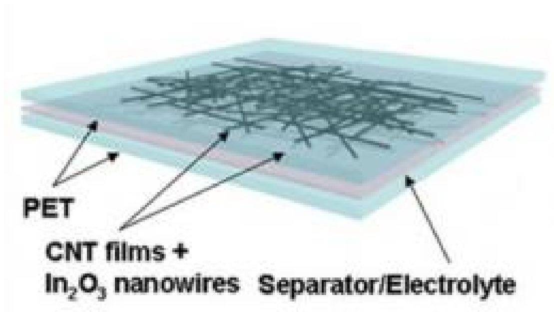


Anatomy of a supercapacitor: two films combining Indium Oxide ($In_2O_3$) separated by a layer of Nafion film. Credit: USC Viterbi School of Engineering

It is a completely transparent and flexible energy conversion and storage device that you can bend and twist like a poker card.

It continues a line of prototype devices created at the USC Viterbi School of Engineering that can perform the electronic operations now usually handled by silicon chips using carbon nanotubes and metal nanowires set in indium oxide films, and can potentially do so at prices competitive with those of existing technologies.

The device is a supercapacitor, a circuit component that can temporarily store large amounts of electrical energy for release when needed. A team headed by Chongwu Zhou describes it a newly-published paper on "Flexible and Transparent Supercapacitor based on Indium Nanowire /

Carbon Nanotube Heterogeneous Films" in the journal Applied Physics Letters (Vol.94, Issue 4, Page 043113, 2009).

Its creators believe the device points the way to further applications, such as flexible power supply components in "e-paper" displays and conformable products.

The device stores an energy density of 1.29 Watt-hour/kilogram with a specific capacitance of 64 Farad/gram. By contrast, conventional capacitors usually have an energy density of less than 0.1 Wh/kg and a storage capacitance of several tenth millifarads.

Zhou, who holds the Jack Munushiun Early Career Chair at the USC Ming Hsieh Department of Electrical Engineering, worked with USC graduate students Po-Chiang Chen and Sawalok Sukcharoenchoke, and post-doc Guozhen Shen.

The group incorporated metal oxide nanowires with carbon nanotubes (CNTs) to form heterogeneous films and further optimized the film thickness attaching on transparent plastic substrates to maintain the mechanical flexibility and optical transparency of the supercapacitors.

According to Zhou, the work, based on combing CNTs with metal nanowiers represents an advance on earlier attempts to produce supercapacitors using just CNTs or graphite.

Such efforts resulted in only modest performance compared to those using transition metal oxide materials, including such oxides of iron, manganese and rubidium. Moreover, energy storage devices made by these materials have neither mechanical flexibility nor optical transparency, which have confined their applications in the flexible and transparent electronics.

The critical improvement in performance, according to the research, can be attributed to the incorporation of metal oxide nanowires with CNT films. Indium oxide nanowire, with the properties of wide band gap, high aspect ratio, and short diffusion path length, can be one of the best candidates for transparent electrochemical capacitors. Professor Zhou's lab has pioneered this material over the past several years.

These new devices, by contrast, "demonstrated enhanced specific capacitance, power density, energy density, and long operation cycles, compared to those supercapacitors made only by CNTs," says the new release.

"We successfully produced a prototype of flexible and transparent supercapacitors built on two important nanostructured materials (including metal oxide nanowires and CNTs).

The researchers not only created metal oxide nanowire / CNT heterogeneous films as active materials and current collecting electrodes for the supercapacitors, but also examined the stability of the transparent and flexible supercapacitors through a large cycle number of charge/discharge measurements.

The paper contains description of how the new devices are made.

"CNT films were fabricated by vacuum filtration method. An adhesive and flat poly (dimethysiloxane) (PDMS) stamp was adapted to peel the CNT film off of the filtration membrane and then released it onto a polyethylene terephtalate (PET) substrate. In2O3 nanowires with a diameter of ~ 20 nm and a length of ~ 5 μm were synthesized by a pulsed laser deposition (PLD) method. The as-grown nanowires were sonicated into IPA solutions and then dispersed upon transferred CNT films to form In2O3 nanowire /CNT heterogeneous film for transparent and flexible supercapacitor study.

"In addition, with the increasing amount of In2O3 nanowires dispersed upon CNT films, the specific capacitance of the heterogeneous supercapacitor can be dramatically improved up from 25.4 Farad/gram to 64 Farad/gram. In comparisons to supercapacitors made by other transition metal oxide nanostructured materials, this observation indicates a good stability of In2O3 nanowire / CNT heterogeneous films for long-term capacitor applications."

Source: University of Southern California (news : web)