Nano World: Nano origami supercapacitors

March 10 2006

Origami with features just nanometers or billionths of a meter large can fold into electrically chargeable supercapacitors, experts told UPI's Nano World.

For decades, the electronics industry has developed a vast body of knowledge when it comes to building flat structures on the nanometer scale. Now scientists want to take advantage of the third dimension as well to create ever more complex and powerful devices, but present manufacturing techniques are not having an easy time growing into this new space, said researcher George Barbastathis, a mechanical engineer at the Massachusetts Institute of Technology in Cambridge.

Instead, Barbastathis and his colleagues hit upon the idea of developing origami, the art of folding paper into complex shapes, into a way of leverage existing 2-D nano knowledge into 3-D. He teamed up with MIT electrochemist Yang Shao-Horn to create flat structures that can fold themselves into electricity storage devices known as capacitors. These are made of pairs of physically separated electrodes that each stores an opposite charge.

"We were able to achieve performance that is comparable to commercial supercapacitors, even though our device was relatively simple. This implies that we could in the future improve further by more sophisticated origamis and surface nanopatterning," Barbastathis said.

First, the researchers patterned carbon electrodes and droplets of sulfuric acid onto a gold membrane using state-of-the-art nanofabrication

techniques. They also patterned on creases and hinges onto the membrane and then simply folded the membrane onto itself using a microscopic probe. The sulfuric-acid droplets both physically separate the carbon electrodes from each other and glue them together.

The origami devices could help power microscopic devices such as micromechanical sensors and actuators. "It is particularly well suited for single-use -- disposable devices or situations where recharging can be performed after use at low cost," Barbastathis said.

Supercapacitors are "a perfect application of the nanostructure origami technology," said University of California at Berkeley electrical engineering professor Ming Wu. "One application that I find particularly interesting is to use it as an energy source to power remote, unattended sensor networks, so-called smart dust. The supercapacitor can be charged by energy-salvaging devices such as solar cells, and the stored energy can sustain the operation of sensor nodes without needing battery replacement, possibly for the entire life of the sensor node."

Moreover, supercapacitors are just one example of a device this origami technique can produce. "One can envision using similar technique to produce stacked thin slices of integrated circuits into 3-D systems," Wu said.

In the future, Barbastathis and his colleagues plan to explore more complicated origami structures and different material combinations for potentially even better results. They have also developed origami structures that can essentially fold themselves, which could in the future help mass produce supercapacitors and other devices without need for manual folding. This self-folding technique relies on membranes that want to curl up, forcing a different membrane bonded on top of it to fold.

"There are many possible directions to go from here. The current structure is folded only once. Like paper origami, it is possible to fold multiple times," Wu said.

Barbastathis and his colleagues reported their findings in the journal Applied Physics Letters.