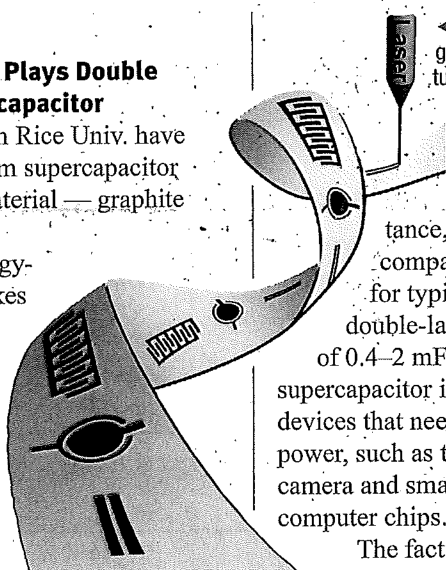
MATERIALS

Graphite Oxide Plays Double Agent in Supercapacitor

Researchers from Rice Univ. have created a thin-film supercapacitor from just one material — graphite oxide (GO).

The new energy-storage device takes advantage of graphite oxide's ability to act as both a good ionic conductor and an electrical insulator, depending on its moisture content. As such, it can serve as both an electrolyte and an electrode separator.



◀ Burning patterns into graphite oxide with a laser turns the thin sheets into fully functional supercapacitors. Image courtesy of Ajayan Lab, Rice Univ.

"The fundamental breakthrough here is that GO, when it contains water, acts as an ionic conductor," says Pulickel Ajayan, a professor of mechanical engineering and materials science and of chemistry at Rice Univ. "So we're able to convert a sheet of GO into a supercapacitor without adding anything. All you need are a pattern and the electrodes, and you have a device," Ajayan says.

To build their supercapacitor, the team scanned a CO_2 laser across the surface of a sheet of graphite oxide to create patterns of conducting reduced graphite oxide (RGO). The areas contacted with the laser are partially reduced, whereas the unscanned areas remain intact, says Wei Gao, a graduate student at Rice. "In this process, we can make any reduced graphite oxide pattern on a graphite oxide surface, just like what we can do when we write on paper with a pen," she says.

The team built several supercapacitor structures, layered both side-by-side and top-to-bottom, with different geometries. The in-plane supercapacitor structure with a circular geometry had the highest capacitance, 0.51 mF/cm^2. This compares to the capacitance for typical electrochemical double-layer microcapacitors of 0.4–2 mF/cm^2. This type of supercapacitor is used to power small devices that need a quick burst of power, such as the flash of a phone camera and small components in computer chips.

The fact that GO can be easily converted to RGO by means of laser radiation enables any number of in-plane or sandwiched RGO–GO–RGO supercapacitor devices to be produced in a scalable and simple manner via laser-patterning of hydrated GO, the researchers say.

Before the supercapacitor can be used commercially, its energy-storage capacity will need to be increased. For now, however, the researchers will focus on understanding the physics and chemistry of why GO works as an electrolyte. This understanding will then be applied to improve the supercapacitor performance, says Robert Vajtai, a faculty fellow at Rice.

Molecules Link Like Tiny Wires to Form Circuits

A new technique for wiring together organic molecules could be the key to realizing molecular electronics.

The developers employ a method they call chemical soldering to connect conductive polymer nanowires to a single molecule. Scanning tunneling microscopy (STM) is used to initiate polymerization. As the polymer chain forms, it moves across a surface coated with the functional organic molecules, picking up the molecules in its path to create a molecular circuit of sorts.

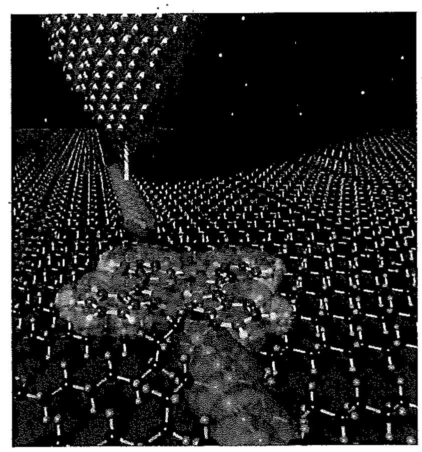
So far, the team, led by Yuji Okawa, a senior researcher at Japan's National Institute for Materials Science (NIMS), has linked together phthalocyanine molecules, which are used in organic semiconductors and solar cells.

Silicon-based electronics are rapidly approaching the theoretical limits on their size and power. At the same time, consumers continue to demand smaller, lighter-weight, multifunctional electronics.

Molecular electronics, in which a single organic molecule behaves as a device such as a diode or transistor, addresses this challenge.

"Since the size of each single molecule is one to a few nanometers, the size of the single-molecule device will be much less than a tenth of the size of conventional silicon-based devices," Okawa says.

However, no one has yet been able to build a practical single-molecule integrated circuit, he adds. One obstacle has been the lack of a practical way to wire these organic molecules together.



▲ To form conductive nanowires, a functional molecule is placed on a molecular layer of diacetylene. Next, an STM probe tip is used to initiate polymerization, thereby forming a conductive polymer nanowire. Because the front end of the polymer chain contains a reactive chemical species, it will chemically bond with the molecules it encounters. Image courtesy of Yuji Okawa, NIMS.