Charging up solar cells

ENERGY GENERATION

Blends of conjugated polymers with fullerenes, polymers, or nanocrystals make promising materials for low-cost photovoltaic applications. Different processing conditions affect the efficiencies of solar cells by creating a variety of nanostructured morphologies. However, the relationship between film structure and device efficiency is not fully understood. David S. Ginger and David C. Coffey from the University of Washington have developed a technique to measure photoinduced charge buildup in polymer solar cells with sufficient spatial resolution to distinguish between efficient and inefficient regions of a nanostructured photovoltaic film [*Nat. Mater.* (2006) **5**, 735].

The signal from an electrostatic force microscope (EFM) was monitored as a function of time while illuminating a sample. It was found that the rate of photoinduced charging under the tip was a good indicator of the photovoltaic efficiency of the material being probed.

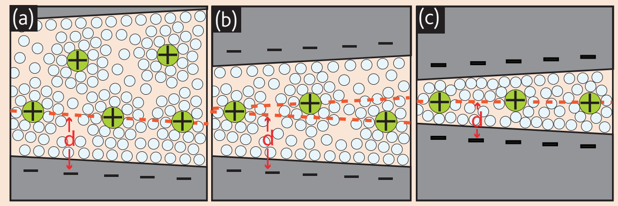
"We did this because many of the most efficient organic solar cells use blends of electron-accepting and electron-donating materials that form microscale and nanoscale structures," explains David Ginger. "To understand how these materials work, one wants to be able to picture what is going on in each region of the blend to answer questions like: where are carriers being created?; where are they being lost to recombination?; and where are they being extracted?"

"By helping to understand how the present generation of nanostructured solid-state solar cells work at the microscopic level, we hope to contribute to improving the performance of these devices," says Ginger.

Peter Dominiczak

Supercapacitors: size matters

ENERGY GENERATION



Solvated ions residing in pores with the distance between adjacent pore walls (a) > 2 nm, (b)between 1 nm and 2 nm, and (c) < 1 nm. As pore size decreases below the diameter of the solvation shell, the ion center approaches the pore wall more closely, leading to improved capacitance. (© 2006 Science.)

Carbon supercapacitors use ion adsorption on the surface of highly porous carbon electrodes to store charge. Studying the effect of the pore size on capacitance has the potential to improve performance by maximizing the available surface area, but until recently, the lower limit of accessible pores had been unknown. It has long been believed that pores smaller than the size of solvated electrolyte ions are incapable of contributing to charge storage. However, scientists from Drexel University and the University of Paul Sabatier, France have proved that the opposite is true – the highest capacitance can be observed for materials with smaller pores [Chmiola *et al.*, *Science* (2006) doi: 10.1126/science.1132195]. By carefully controlling the nanoscale structure of a carbide-derived carbon, the researchers increased the charge-storing capacity of a supercapacitor by about 50%.

The researchers believe that the solvation shells of ions become highly distorted in the subnanometer pores, which decreases the ion-to-carbon distance and allows more ions to cover the carbon surface, thus leading to increase in the energy storage. While the exact mechanism is not yet clear and simulations need to be performed to better understand the behavior of ions in the pores, the simplified explanation is that a carbon pore, when of similar size to an ion and charged oppositely to it, takes over the function of the solvation shell – screening the ions from each other.

"Supercapacitors could be better alternatives to batteries in applications such as uninterruptible power supply devices, electrical vehicles, and portable electronics" says Yury Gogotsi of Drexel. "The combination of supercapacitors with batteries, fuel cells, and even internal combustion engines could provide unprecedented efficiency, power, and energy characteristics of such systems."

Peter Dominiczak

Nanotubes mimic nature

ENERGY GENERATION

Scientists from the California NanoSystems Institute at the University of California, Los Angeles (UCLA) have developed a system using single-walled carbon nanotube (SWNT) field-effect transistors (FETs), functionalized noncovalently with a Zn porphyrin derivative, to detect photoinduced electron transfer directly within a donor/acceptor system. This research could form the basis for applications in artificial photosynthesis and alternative energy sources such as solar cells [Hecht *et al.*, *Nano Lett.* (2006) doi: 10.1021/nl061231s].

Direct conversion of environmental effects into electronic signals lies at the heart of the human sensory system and the researchers' work is a step toward creating a complex device based on this principle. The scientists take porphyrin – a light-absorbing molecule that triggers a charge-rearranging reaction in plants – and combine it with a transistor. The conducting channel of the transistor is formed by a network of carbon nanotubes. This system mimics part of the natural process of photosynthesis or, more specifically, the use of a light-harvesting material to initiate an electron transfer. However, unlike photosynthesis, the absorption of light in this system initiates the transfer of holes rather than electrons from the porphyrin. By measuring the electronic response as function of the wavelength and light intensity and comparing it with the optical absorption spectrum of porphyrin, the charge-rearranging process can be identified directly.

"By using a transistor – instead of resistors for example – one can directly measure the light-induced charge transfer from the molecule to the electronic device, and our experiments give direct evidence for such processes," says George Grüner of UCLA. "The work has an implication for light sensing and also for the possibility of a variety of optoelectronic devices based on the charge-transfer process that has been identified. For example, it can be regarded as a first step towards an artificial eye." The researchers have also demonstrated that the transistors can be fabricated onto any – even a biocompatible – substrate, and are small enough so that an array containing many transistors can be fabricated.

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