SNS, HFIR experiments help refine thin-film solar cells

September 2 2011

(PhysOrg.com) -- Solar cells that convert sunlight into electricity could be a widely used renewable energy source. Getting to that point, though, requires breakthroughs in their cost and their efficiency at turning sunbeams into electric current. Neutron scattering experiments conducted at Oak Ridge National Laboratory are helping solar cell makers obtain the hard data they need to refine their materials and manufacturing processes.

One of the most promising options for lowering costs is to make solar cells from thin films made up of combinations of plastics called polymers. These devices are easy to produce in large numbers because they use conventional industrial processing methods, which are relatively cheap and energy-efficient compared to the processes used to make the silicon solar cells that are most widely used now. Also, panels made from organic solar cells are lighter and less expensive to install than the bulky solar panels made from silicon cells.

The drawback to these easily fabricated thin-film devices is their power conversion efficiency, or how well they convert solar radiation to electricity. They're much less efficient than silicon cells (which are almost 30 percent efficient). To be inexpensive enough to compete with silicon cells, thin-film solar cells must be more than 10 percent efficient, but so far, the best ones are only about 8.3 percent efficient. To make solar cells efficient enough, scientists need to understand the molecular structure of the thin films they're made of, how the structure relates to the efficiency of the solar cell, and how to tailor the structure for the

greatest efficiency.

Recent studies of polymer-based solar cells at ORNL's Spallation Neutron Source and High Flux Isotope Reactor revealed important details about their molecular structure and showed that annealing (heat treating) the devices improves their power conversion efficiency. The experiments showed that annealing solar cells appropriately as they are fabricated improves their efficiency by more than 20 percent compared to films that aren't annealed.

"We are trying to use mixtures of photoactive polymers to absorb light over a broad wavelength range to improve efficiency," said principal investigator Thomas Russell of University of Massachusetts-Amherst. Haiyun Lu of U-Mass and Bulent Akgun of the NIST Center for Neutron Research and the University of Maryland are co-investigators. Studies such as this one are key to improving the performance of polymer-based solar cells so that they can compete in the marketplace.

The device studied consisted of two semiconductor materials deposited in a thin film on an underlying plate. The films were examined in their original state after being deposited and then after annealing. The MAGICS magnetism reflectometer at the SNS investigated the vertical arrangement of the layers in the film, and the General Purpose Small-Angle Neutron Scattering instrument at HFIR showed how well the two semiconductors blended.

"Structural characterization of thin films has always represented a challenge for small-angle neutron scattering," said Yuri Melnichenko, lead scientist at GP SANS. A powerful neutron beam is needed to monitor the subtle structural changes that occur during the formation of the film, and HFIR provides one of the strongest neutron beams for SANS in the world. The experiments at HFIR were completed within approximately 24 hours, while similar measurements at less intense

neutron sources would require five to seven days, Melnichenko said.

How well the semiconductor materials in the thin film blend is important to their performance. The measurements on MAGICS showed that the blending of the two semiconductors increased steadily as the sample was annealed for up to one minute, said Valeria Lauter, lead scientist for MAGICS. As heating continued beyond one minute, there was little further change in the blending.

The experiments determined that annealing the solar cell at 150 degrees Celsius for one minute at a particular point in the process improved its efficiency by slightly over 20 percent compared to the original film. Annealing for shorter times improved the efficiency by lesser amounts. Annealing for more than a minute caused it to decline, as did annealing it at a different point in the process.

The work is detailed in the paper "Morphological characterization of low-bandgap crystalline polymer: PCBM bulk heterojunction solar cells," in *Advanced Energy Materials*, available online at neutrons.ornl.gov/research/hig … rization_russell.pdf

Provided by Oak Ridge National Laboratory