

Nanoparticle technique could lead to improved semiconductors

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Devices made from plastic semiconductors, like solar cells and light-emitting diodes (LEDs), could be improved based on information gained using a new nanoparticle technique developed at The University of Texas at Austin.

As electrical charges travel through plastic semiconductors, they can be trapped much like a marble rolling on a bumpy surface becomes trapped in a deep hole. These traps of charges are known as “deep traps,” and they are not well understood.

Deep traps can be desired, as in the case of plastic semiconductors used for memory devices, but they can also decrease the efficiency of the material to conduct electrical charges. In the case of solar cells, deep traps can decrease the efficiency of the conversion of light into electricity.

To further explore the deep trap phenomenon, a group of scientists led by Professors of Chemistry and Biochemistry Paul Barbara and Allen Bard developed a single-particle technique to study small portions of semiconductor material at the nanoscale.

The scientists reported their findings in the advanced online issue of the journal *Nature Materials*.

“Our results strongly suggest that deep traps are formed in plastic semiconductors by a charge induced chemical reaction,” says Dr.

Rodrigo Palacios, lead author and post-doctoral fellow at the Center for Nano and Molecular Science and Technology. “These traps were not there in the uncharged pristine material.”

Deep traps could be caused by defects in the semiconductor material—either native to the material or introduced impurities—with special properties that encourage charge trapping. The traps also could develop over the life of the semiconductor.

Previous techniques used to study deep traps have generally involved completed semiconductor devices, which Palacios says creates complications due to the complexity of a functional device.

For the current study, Palacios used a conjugated polymer (plastic semiconductor) material known as F8BT, which is commercially available and has promising applications in organic LEDs and solar cells.

He produced particles of F8BT with diameters about one-ten thousandth that of a human hair. He then shone light on the nanoparticles and measured changes in intensity of the resulting fluorescence. (This type of semiconductor material takes in light energy and releases part of this energy as light of a different color.)

Palacios observed deep traps forming as he electrochemically charged and discharged the semiconductor nanoparticles. The deep traps led to decreases in light emission from the material.

“With our new technique, we got detailed information on how these deep traps are formed and how long they live,” says Palacios. “In principle, this kind of information can be used to improve devices made out of these conjugated polymers, designing new materials that can avoid these deep traps or materials that might be able to form these deep traps better.”

Source: University of Texas at Austin

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