Research helps overcome barrier for organic electronics

November 10 2009, BY DAVID ORENSTEIN

Engineered organic semiconductor crystals such as these are used to study the effects of current flow in thin film transistors that could be useful in digital displays and flexible electronics.

(PhysOrg.com) -- Electronic devices can't work well unless all of the transistors, or switches, within them allow electrical current to flow easily when they are turned on. A team of engineers has determined why some transistors made of organic crystals don't perform well, yielding ideas about how to make them work better.

Providing insight into a frustrating inconsistency in the performance of electronics made with organic materials, Stanford researchers have shown that the way boundaries between individual crystals in a film are aligned can make a 70-fold difference in how easily current, or electrical charges, can move through transistors.

The research, which could help engineers design better digital displays and other devices, was published online Nov. 8 in the journal Nature Materials.

Organic semiconductors have a lot to offer in electronics. They are cheap and flexible, and the production process is much simpler than for traditional silicon chips. Applications such as computer display screens, digital signs or magazines made of "electronic paper" have been possibilities for more than a decade, but their full potential seems always just around the corner. A persistent problem is that performance from transistor to transistor varies much more than can be allowed in commercially viable devices.

"You can make a single device that has high 'charge mobility,' but you really need to make thousands of them," said Alberto Salleo, an assistant professor of materials science and engineering at Stanford and a senior co-author of the paper. "Most research groups report a high variation in that mobility. What we did here is try to understand what causes the variation."

Systematic study

Salleo's group led a multidisciplinary team of researchers in making a systematic study of a likely culprit of the inconsistent transistor performance in polycrystalline devices: the "grain" boundaries between crystals. It turns out that the differences in boundary alignment can make the path that electric charges must follow through a transistor look more like a disjointed slog through airport security than a sprinter's dash.

To examine the role that boundary alignment plays, the paper's lead author, graduate student Jonathan Rivnay, grew crystals of an organic semiconductor called PDI8-CN2, synthesized at Northwestern University and Polyera Corp., an organic electronics company, using a process that ensures consistent alignment from crystal to crystal in a particular direction.

He then made transistors in which charges could flow through molecules that were well aligned with each other, and others where the molecules were misaligned across the grain boundaries. The first kind of transistors performed far better. He went further to link the properties of these boundaries to the molecular packing in the crystals.

In addition to the team's direct electrical measurements, the researchers employed information from extensive theoretical calculations, made by co-author John E. Northrup at Xerox Palo Alto Research Center, and with X-ray analysis headed by co-author Michael Toney at the Stanford Synchrotron Radiation Lightsource.

Could influence future production

Rivnay said the team's work could strongly influence how organic crystal electronics are made in the future.

"The problem of understanding defects in organic electronic materials including grain boundaries is very important for any device application," Rivnay said. "By better understanding what goes on at these boundaries, and how detrimental they are, improvements can be made at the chemistry end as well as at the design and fabrication end of the process. This way devices can be more reproducible and better performing."

Other authors were Stanford graduate students Leslie Jimison in Materials Science and Engineering and Rodrigo Noriega in Applied Physics; Northwestern University chemist Tobin Marks; Polyera Corp.

researcher Shaofeng Lu; and Northwestern faculty member and Polyera Chief Technology Officer Antonio Facchetti. Funding came from multiple U.S. federal institutions, including the departments of Defense and Energy and the National Science Foundation, as well as the King Abdullah University of Science and Technology in Saudi Arabia.

Provided by Stanford University (news : web)

Citation: Research helps overcome barrier for organic electronics (2009, November 10) retrieved 24 April 2024 from https://phys.org/news/2009-11-barrier-electronics.html