Polarized X-ray scattering technique reveals structure of printable electronics

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(Phys.org) -- An innovative X-ray technique has given North Carolina State University researchers and their collaborators new insight into how organic polymers can be used in printable electronics such as transistors and solar cells. Their discoveries may lead to cheaper, more efficient printable electronic devices.

Printable electronics are created by spraying or printing inks containing conductive organic molecules onto a surface. The process is fast and much less expensive than current production techniques for items like solar cells or computer and television displays. Additionally, it holds potential for amazing new applications: picture a wearable interactive display that needs no batteries. In the solar industry, the ability to print solar cells on giant roll-to-roll printing presses – like printing a newspaper – could make the technology much more affordable and mass marketable.

NC State physicists Dr. Harald Ade and Dr. Brian Collins, in collaboration with Dr. Michael Chabinyc at the University of California Santa Barbara, wanted to know why some processing steps resulted in better and more efficient devices than others. "Manufacturers know that some materials work better than others in these devices, but it's essentially still a process of trial and error," Ade says. "We wanted to give them a way to characterize these materials so that they could see what they had and why it was working."

To do that, Collins and Ade went to Lawrence Berkeley National

Laboratory's Advanced Light Source (ALS). They developed a new technique which used the powerful X-rays from the ALS to look at how individual molecules within these materials organize. They found that the best performing devices were characterized by particular molecular alignments within the materials.

"In transistors, we found that as the alignment between molecules increased, so did the performance," Collins says. "In the case of the solar cells, we discovered alignment of molecules at interfaces in the device, which may be the key to more efficient harvesting of light. For both, this was the first time anyone had been able to really look at what was happening at the molecular level."

The researchers' results appear in the journal *Nature Materials*. Led by NC State and UCSB, an international collaboration of researchers from Lawrence Berkeley National Laboratory, Monash University in Australia, and University Erlangen-Nuremberg in Germany contributed to the work.

"We're hoping that this technique will give researchers and manufacturers greater insight into the fundamentals of these materials," Collins says. "Understanding how these materials work can only lead to improved performance and better commercial viability."

More information: B. A. Collins, et al., "Polarized X-ray scattering reveals non-crystalline orientational ordering in organic films", April 15th 2012, *Nature Materials.*

Abstract:
Molecular orientation critically influences the mechanical, chemical, optical and electronic properties of organic materials. So far, molecular-scale ordering in soft matter could be characterized with X-ray or electron microscopy techniques only if the sample exhibited sufficient

crystallinity. Here, we show that the resonant scattering of polarized soft X-rays (P-SoXS) by molecular orbitals is not limited by crystallinity and that it can be used to probe molecular orientation down to size scales of 10 nm. We first apply the technique on highly crystalline small-molecule thin films and subsequently use its high sensitivity to probe the impact of liquid-crystalline ordering on charge mobility in polymeric transistors. P-SoXS also reveals scattering anisotropy in amorphous domains of all-polymer organic solar cells where interfacial interactions pattern orientational alignment in the matrix phase, which probably plays an important role in the photophysics. The energy and q-dependence of the scattering anisotropy allows the identification of the composition and the degree of orientational order in the domains.

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