Designing Better See-Through Contacts for Displays and Solar Power

New transparent materials for use in liquid-crystal displays, light emitting diodes, photovoltaic cells, and other optoelectronic devices are being developed by researchers from the U.S. and South Korea and investigated utilizing high-brightness x-rays from the APS. The researchers' focus on the structure and properties of amorphous thin films made from zinc (Zn) tin (Sn) oxide (a-ZTO) could lead to less costly devices with none of the disposal problems of other experimental devices that use toxic indium and gallium compounds.

Many amorphous metal-oxide semiconductor materials are transparent and have potential in optoelectronic devices in which transparency and the ability to transmit light is just as important as the ability to carry a current, a flow of electrons. The fact that these materials are amorphous, with no crystalline order, also means that they cannot, by definition, have crystal structure defects, which also means greater electron mobility and faster operation with no barriers thrown up by random defects. In addition, amorphous materials can be grown at low temperatures, thereby reducing thermally induced defects during fabrication.

Other researchers have worked with amorphous indium-gallium-zinc-oxide, but the researchers in this study from the Massachusetts Institute of Technology, Harvard University, Chonnam National University (South Korea), and the Illinois Institute of Technology point out that indium and gallium are much more expensive than other metals with potential such as tin, as well as having toxicity problems. This makes indium and gallium compounds less attractive overall for consumer products from both the end-user safety perspective and in terms of recycling and disposal when the device reaches end of life. The team believes that with appropriate structural control and the right setup tin might provide the necessary electron mobility and transparency characteristics to displace its indium or gallium counterparts.

Indeed, other researchers have investigated methods for making high-quality zinc tin oxide films including sol-gel methods, sputtering, pulsed laser deposition, and the most promising: atomic layer deposition (ALD). The team explains that ALD allows them to control more precisely the exact proportions of each element as they are deposited on the thin layer, which is being grown on a smooth quartz surface at 120° C from the organometallic starting materials diethylzinc and a cyclic tin amide compound.

Specifically, controlling the ratio of tin to zinc atoms allows optoelectronic properties to be tuned and optimized for solid-state device applications. The significant impact of the zinc/tin ratio of a-ZTO thin film on device performance suggests a strong correlation between the atomic structure and electronic transport properties of the films. Because amorphous materials can exhibit a continuum of structures, a local probe is required.

The team used synchrotron x-ray absorption spectroscopy (XAS) at the MR-CAT 10-ID-B beamline to probe the chemical environment of zinc and tin atoms and investigate how the local atomic structure of an amorphous thin film of a-ZTO affects its electron transport properties (Fig. 1). Both quantitative extended x-ray absorption fine structure and qualitative x-ray absorption near-edge structure

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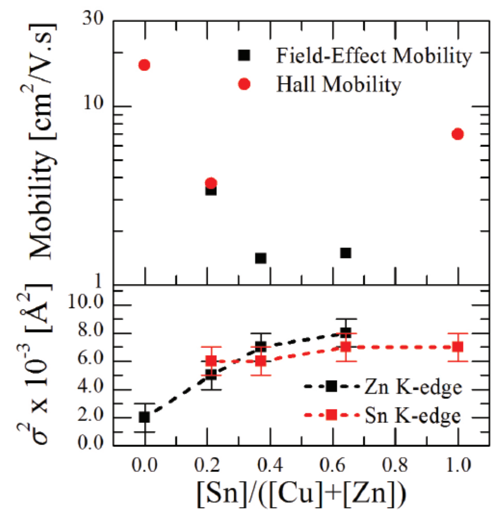

Fig. 1. Field-effect and Hall-effect mobilities and pseudo-Debye-Waller factors are plotted against film composition, [Sn]/([Sn]+[Zn]).

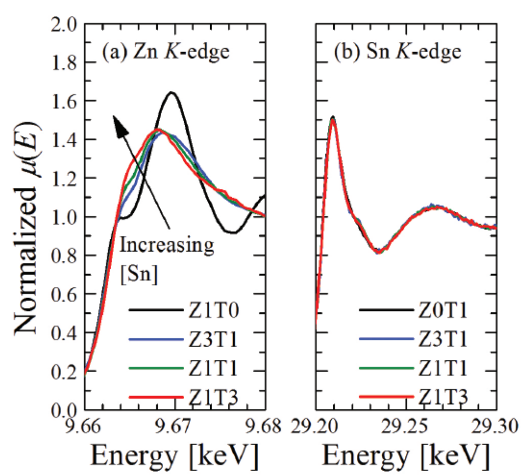

Fig. 2. XANES spectra at (a) Zn and (b) Sn K-edges.