Anomalous Surface Conductivity in In_2O_3 Transparent Conductors

Scientists in the Center for Inverse Design observed a dramatic new property in the class of transparent-conducting contacts that may significantly and beneficially change the way in which they are used in solar cells, displays, and low-e windows.

Transparent conducting oxides (TCOs) are a unique class of materials that exhibit the almost contradictory properties of transparency and conductivity. Without intentional doping, most TCOs behave as insulators. However, we have observed an anomalously high surface conductivity in very high-quality, *undoped*, single-crystal indium oxide (In_2O_3) films grown by pulsed laser deposition. This desirable, but unexpected, effect produces conductivities at the surface comparable to intentionally doped commercial materials.

We employed a combination of electronic structure calculations and direct transport measurements to identify the mechanism of this effect. We showed that conductivity in the thin films is dominated by an unexpected high density of surface donors. This represents an unexpected result that changes our overall view of the nature of TCOs and will lead to a dramatically different approach to their use in the future.

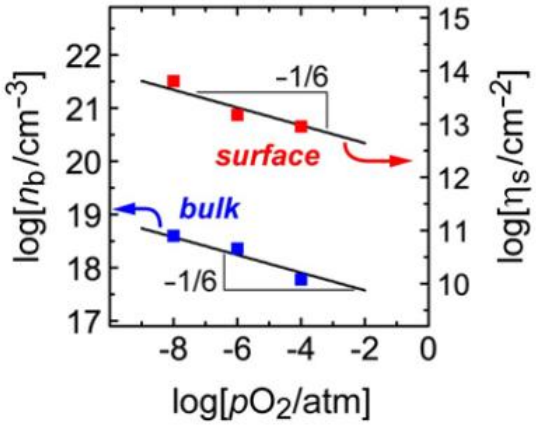

Figure: The density of electronic carriers in the bulk and on the surface for single-crystal In_2O_3 films as a function of the oxygen pressure during growth. Note that the numbers for the bulk are a 3D density and those for the surface are a 2D density—showing almost a carrier per surface atom, much higher than the bulk.

Reference: S. Lany, A. Zakutayev, T.O. Mason, J.F. Wager, K.R. Poeppelmeier, J.D. Perkins, J.J. Berry, D.S. Ginley, and A. Zunger, "Surface origin of high conductivities in undoped In_2O_3 thin-films," *Phys. Rev. Lett.,* **in press** (2011).