Semiconducting Transparent Conducting Oxides: Probing Electronic Structure

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Oxide semiconductors have become of great technological interest and importance in recent years with enormous opportunities to improve existing materials and device applications. This is particularly true for a sub-group of materials that display both optical transparency and high electrical conductivity, the so-called transparent conducting oxides (TCO's). The fact that some of these materials, such indium tin oxide (ITO), have been around for many years and have seen significant industrial use in a relatively low quality form, has perhaps contributed to the belated recognition of the possibilities of using these materials as semiconductors in their own right. Here, the surface and bulk electronic properties of epitaxially grown high-quality oxide semiconductors (CdO and SnO_2) will be discussed and the effects of modifying these surfaces by controlled adsorption and surface treatment. The electronic properties of the resulting oxide materials will be presented. The valence band density of states and the surface electronic properties of these oxide semiconductors have been studied using high-resolution angle-resolved photoemission spectroscopy (ARPES), while core-level photoemission spectroscopy (HAXPES) has been achieved with hard x-rays (E > 2,500 eV), and the results compared with theoretical DFT band structure calculations [1, 2]. A common property of these oxide semiconductors is found to be the presence of an electron accumulation layer at the surface. While this is similar to materials such as InN, it is in marked contrast to the electron depletion typically observed at the surfaces of conventional III-V and II-VI semiconductor materials. More unusual still is the quantized nature of this surface 2D electron gas [3]. Additionally, in these TCO's hydrogen is found to be a donor and any native defects have a propensity to be donors in what are already *n*-type materials. The origins of these phenomena will be discussed in terms of the band structure and intrinsic properties of the materials.

References

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