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Electron Accumulation at Semiconducting Surfaces

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The phenomenon of electron accumulation has been observed and identified at the surfaces of numerous semiconducting materials, including ZnO and InAs, and is in marked contrast to the electron depletion typically observed at the surfaces of conventional III-V, II-VI and Group IV semiconductor materials. However, with the advent of high-quality epitaxially grown materials, a more general model of surface electron accumulation has been developed – particularly following the discovery of this phenomenon at the surfaces of the Group-III nitride material, indium nitride (InN). More recently still, electron accumulation has been observed at the surfaces of a particular sub-set of epitaxial oxide semiconductor materials, that display both optical transparency and a high degree of electrical conductivity, the so-called transparent conducting oxides (TCOs). In this presentation examples from the surface and bulk electronic properties of InN, In-rich InGaN, and several epitaxially grown oxide semiconductors, including In2O3, CdO and ZnO, will be discussed along with the effects of modifying their surfaces by controlled adsorption. The valence band density of states and the surface electronic properties of these materials have been studied using high-resolution synchrotron radiation angle-resolved photoemission (SR-ARPES) and core-level photoemission spectroscopy with hard x-rays (HAXPES), and these data are compared with theoretical DFT band structure calculations. The origins of the phenomenon of surface electron accumulation and the quantized nature of the surface 2D electron gas, will be discussed in terms of the band structure and intrinsic properties of these materials.

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