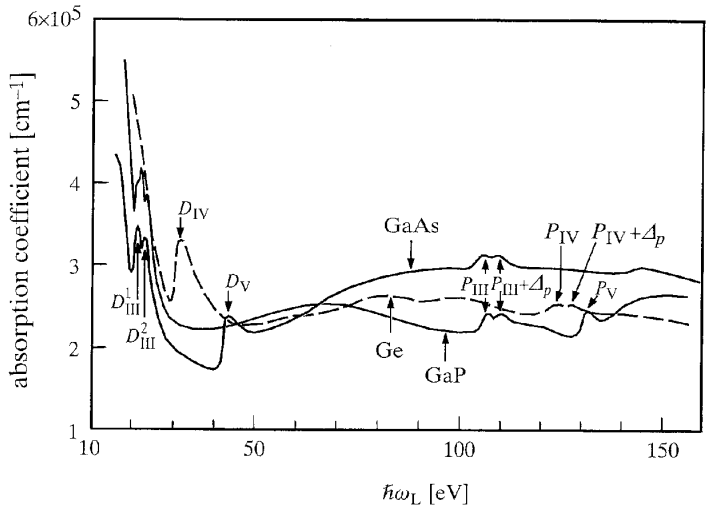


Fig. 8.2. Absorption spectra of GaP, GaAs and Ge.

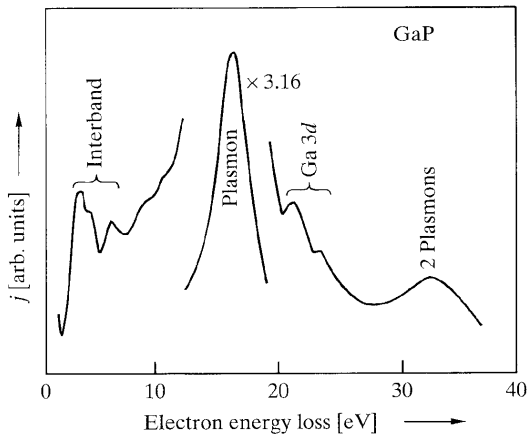
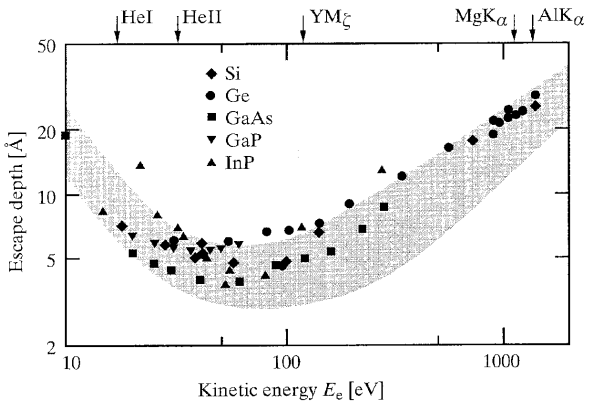


Fig. 8.3. EELS spectrum of GaP.

Auger transition

Surface sensitivity

Photons can be emitted from the surface layer of about 200 Å thick. Thus, essentially bulk properties can be probed.



The emitted electrons are more surface sensitive. See the escape depth–energy dependence in Fig. 8.5.

8.1. Photoemission (XPS, UPS)

The *photoelectric effect,* i.e. emission of electrons from a metal under illumination of UV light, is photoemission of the conduction electrons of the metal. The maximum kinetic energy of emitted electrons is

$$E_e = \hbar\omega_L - I, \qquad (8.2)$$

where $\hbar\omega_L$ is the incident light quantum energy and I is sc. *photothreshold energy* (or *work function* for metals).

For semiconductors the photothreshold energy is typically $5 - 7$ eV, which can be lowered by deposition of (a monolayer of) metal on the semiconductor surface.

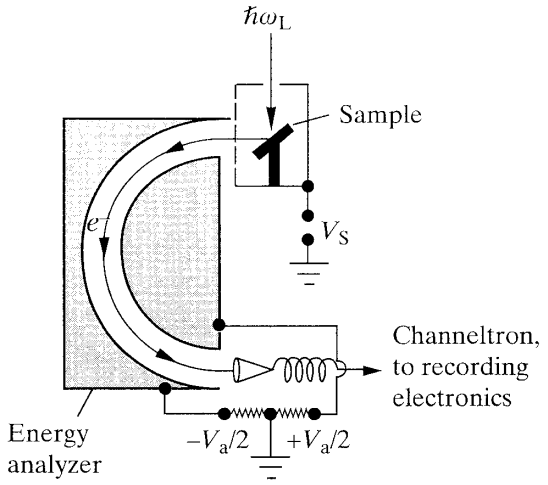
Photon sources

- for UPS
- for XPS
- synchrotron radiation

Electron energy analyzers

Use electric and/or magnetic fields (Lorentz force) to separate ballistic electrons, cf. mass spectrometer for ions.

Fig.8.9. Hemispherical photoelectron spectrometer.



Photoemission models

Photoemission can be described with the *one-step model,* where the initial state consists of the photon and the electrons in the ground state. In the final state, after the photon absorption, the photoelectron is in an initially empty state outside of the solid.

An approximation to the above is the *three-step-model:*

1. Excitation of the electron to an empty conduction band state following the photon absorption.
2. Ballistic transport of the photoelectron to the surface.
3. Transmission of the photoelectron through the surface.

8.2. Inverse Photoemission

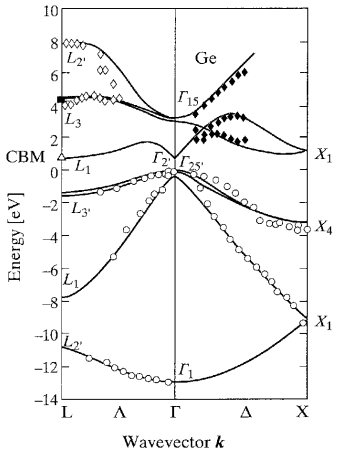


Fig. 8.23 Measured band structure of Ge.

8.3. Surface Effects

Surfaces break the 3D periodicities and by that effect on the electronic structures, most clearly seen as new electronic states.

8.3.1. Surface States and Surface Reconstruction

Cleaving the semiconductor and creating the surface breaks bonds and leaves signly occupied *dangling bonds* pointing out of the surface. These states form 2D bands, which may appear in the bulk band gap as surface states. If they, however, overlap in energy with bulk bands, they may broaden to surface resonances.

Unsaturated dangling bonds may also try to become saturated by *surface reconstruction.* This is analogous to *Peierls transition,* where a half-occupied (metallic) band splits to two: fully occupied and empty, by doubling the primitive cell size (bulk reconstruction).

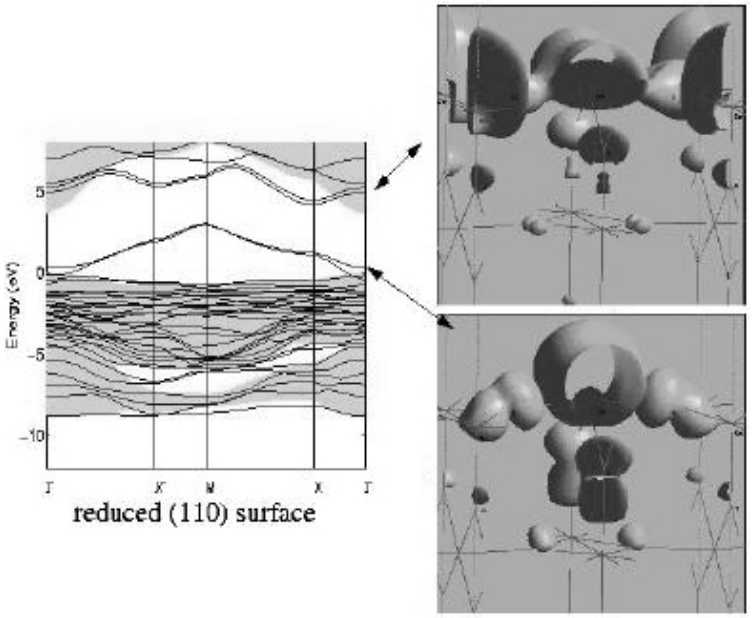


Fig. Reduced (110) surface bands of SnO2. Bulk projection shown by green.