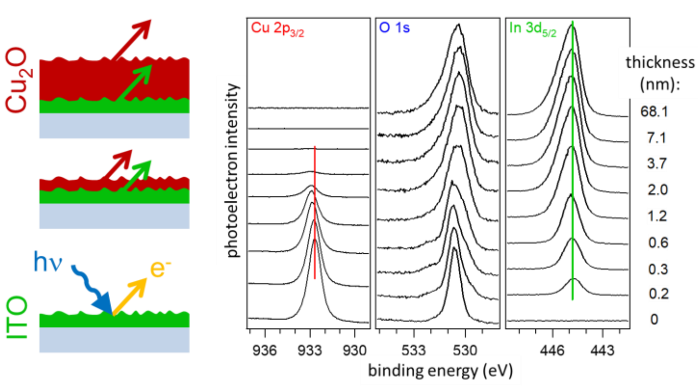
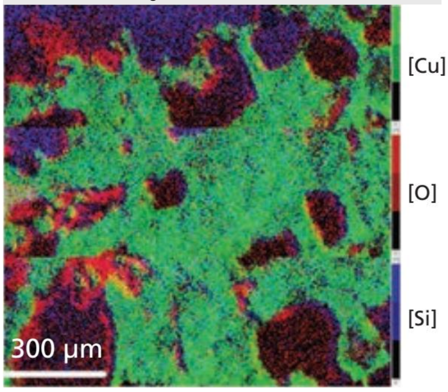
Interface formation between Cu_2O and indium-tin oxide (ITO) measured by XPS



Photoelectron image of a cleaved mineral surface



X-ray and Ultraviolet Photoelectron Spectroscopy (XPS/UPS)

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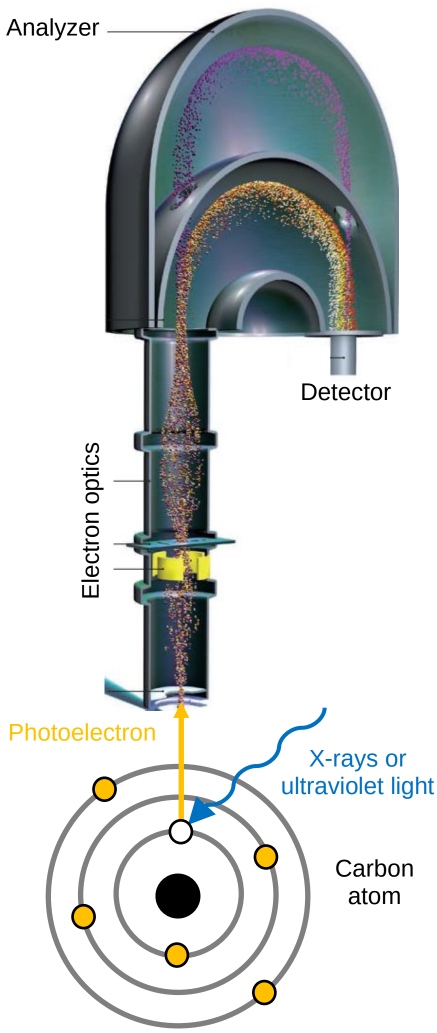
XPS/UPS Principle

Photoelectron spectroscopy is a surface analysis tool for chemical and electronic characterization of materials. Its distinguishing feature is the possibility to measure chemical states. The information depth is 1-9 nm.

The electrons of an atom are distributed over quantized energy levels. In a compound, the valence electrons of the elements interact, which changes the electrostatic potential inside the atom. This causes the chemical shift in the binding energy, which allows to quantify the oxidation states of a material. External changes in the electrostatic potential also cause shifts, which provide information about surface and contact potentials, relevant for the function of electronic devices.

The technique relies on the photoelectric effect. The photoexcitation energies typically range from ~20 eV (UPS) to ~1.5 keV (XPS). The photoelectrons are filtered regarding their kinetic energy by the analyzer and counted by the detector. The lower the kinetic energy of the photoelectron, the more tightly it was bound to the nucleus, so the higher is its binding energy.



Technical information

Specifications

- Excellent compromise between energy resolution and sensitivity:

  0.44 eV at 200 kcps (XPS)

  0.60 eV at 2 Mcps (XPS)

  0.01 eV at 1 kcps (UPS)
- Lateral resolution for spectroscopy: 15 µm
- Imaging capability with lateral resolution of 1 µm and infinite size (by image stitching)
- Rapid "snapshot" spectroscopy
- Angle-resolved measurement and azimuthal rotation
- Pressure in analysis chamber down to 5e-10 Torr
- Sample holder size 9 x 3 cm

Main features

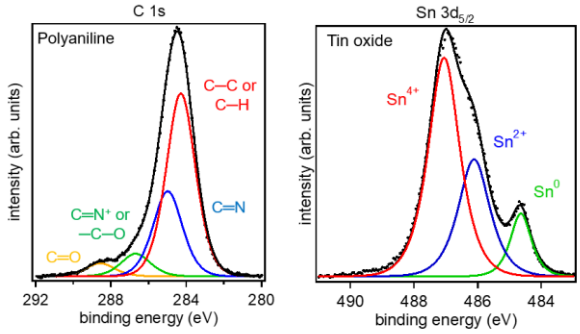
- 165 mm mean radius hemispherical and spherical mirror analyzer
- Delay-line detector
- Magnetic immersion lense
- Electron-only charge neutralization
- Monochromatic Al source (1486.6 eV)

Accessories

- Argon cluster sputter gun (up to 2000 atoms)
- Heating and cooling in load-lock and analysis chamber (-120°C to 800°C)
- Helium discharge lamp for UPS (He I: 21.22 eV, He II: 40.8 eV)
- Ion scattering spectrometry (ISS)
- Dual achromatic source (Al/Mg)
- Sample transfer chamber for transport of air-sensitive

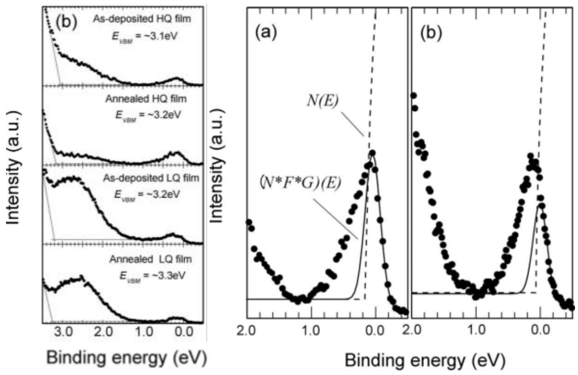
Chemical shift and fitting of photoemission lines

Fitting with mixed Gauss-Lorentz profiles is employed to deconvolute the individual components of an emission line. Both covalent and ionic bonds can be quantified.



Electronic states inside the band gap

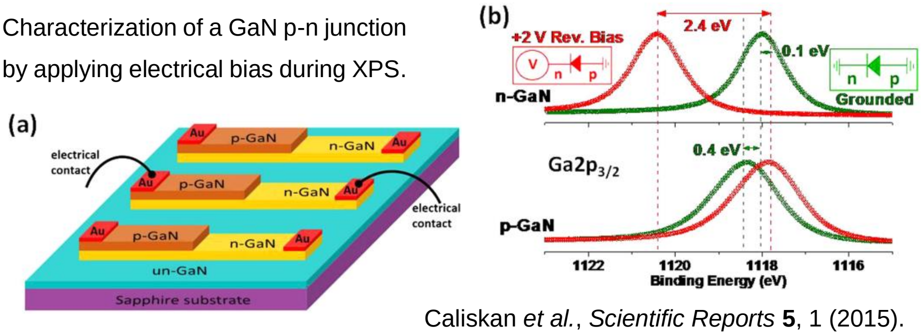
Probing subgap states in the transparent amorphous oxide semiconductor In–Ga–Zn–O by bulk sensitive XPS (photon energy: 7935.2 eV).



Nomura *et al.*, *APL* **92**, 202117 (2008).

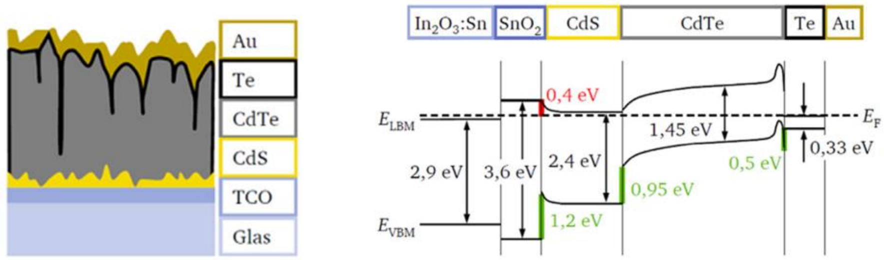
Measurement under external bias

Characterization of a GaN p-n junction by applying electrical bias during XPS.



Caliskan *et al.*, *Scientific Reports* **5**, 1 (2015).

Energy band alignment at interfaces



Klein, *J. Phys. Condens. Matter* **27**, 134201 (2015).

Sputter depth profiling

Sputter depth profile of multilayer coatings on glass, using clusters of 500 argon atoms with an energy of 20 keV.