thermoscientific

QUICK GUIDE

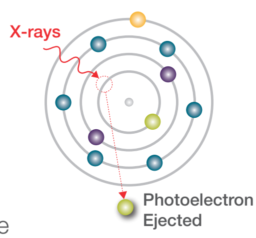
X-ray Photoelectron Spectroscopy

Electron spectroscopy for chemical analysis

In brief...

- Sampling depth 5–10 nm from the top surface
- Elemental quantification for all elements Li and above except H and He
- Quantitative chemical information
- Detection limits ~ 0.1 At.%
- Composition profiles for thin films and interfaces when combined with ion profiling
- Elemental and chemical state surface distribution when used in imaging mode

Basic theory



X-ray photoelectron spectroscopy (XPS), also known as electron spectroscopy for chemical analysis (ESCA), relies upon Einstein's photoelectric effect, in which an X-ray photon removes an electron from an atom or molecule. The kinetic energy of that electron depends upon the photon energy and the energy required to remove the electron (the binding energy) according to the equation:

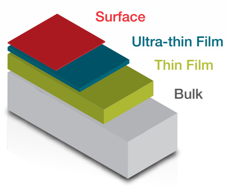
Photon Energy (Known) – **Kinetic Energy** (Measured) = **Binding Energy** (Calculated)

In an XPS spectrometer, the kinetic energy of the emitted electron is measured. Typically, a monochromatic X-ray source of a known energy, e.g., Al Kα radiation at 1486.6 eV, is used in the excitation. This allows the binding energy of the emergent electron to be easily calculated from the equation above. Since the binding energy is characteristic of the chemical environment of the parent atom, it is possible to quantify not only the elemental composition of the surface, but also the chemical composition.

Technology

Ultra-high vacuum (UHV) is required to increase photoelectron path length and maintain sample cleanliness. The X-ray source for excitation of photoelectrons is usually Al or Mg Kα radiation. A concentric hemispherical electron analyzer is used for measuring the kinetic energy of the emitted photoelectrons, with channeltrons or channelplates for detection. Systems are typically configured with both a charge compensation system for insulator analysis and a profiling source for depth composition analysis.

Applications



XPS is used for the analysis of solid surfaces, thin films, and interfaces. The technique is considered to be standard-less, requiring no external calibration to obtain quantified results. It also requires little or no sample preparation.

The number of application areas in which XPS is used is extensive, encompassing both academic and industrial research and development, QA/QC, and contract laboratories.

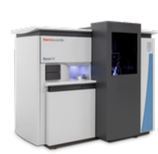
These areas include:

- Measuring surface contaminants
- Ultra-thin film and oxide thickness measurements
- Characterization of surface defects, stains, and discolorations
- Measuring effect of surface preparation treatments
- Composition of powders and fibers
- Chemical characterization of plasma-modified polymer materials
- Measurement of coating thickness and conformity
- Composition depth profiling for multilayer and interface analysis

Thermo Scientific XPS instruments

Our instruments, software, and services empower you to solve for complex analytical challenges by addressing a range of needs from sample prep to material characterization to chemical analysis.

K-Alpha
XPS System



Nexsa G2
XPS System

ESCALAB XI+
XPS Microprobe

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