A quick NPL guide to…

X-Ray Photoelectron Spectroscopy

What does XPS do?

XPS is used for investigating the surface chemistry of electrically conducting and non-conducting samples. It provides the following information from the top 10nm of a sample with a spatial resolution between three to a few hundred μm.

- Elemental composition with up to 0.1% sensitivity
- Chemical state information
- Thickness measurement of overlayers of up to 8 nm on a substrate
- Surface chemical imaging with a resolution of 3 μm
- Angle resolved XPS for thickness and depth-distribution of chemical species
- Depth profiling using an ion gun to sputter away the surface during analysis
- Ultraviolet photoelectron spectroscopy (UPS) available in the same instrument provides information on the density of states in the valence band and electron work function

How does XPS work?

A surface is irradiated with X-rays (commonly Al Kα or Mg Kα) in vacuum. When an X-ray photon hits and transfers this energy to a core-level electron, it is emitted from its initial state with a kinetic energy dependent on the incident X-ray and binding energy of the atomic orbital from which it originated. The energy and intensity of the emitted photoelectrons are analysed to identify and determine the concentrations of the elements present. These photoelectrons originate from a depth of <10 nm therefore the information obtained is from within this depth. UPS uses a much lower energy source, He(I) and He(II), 21.2 eV and 40.8 eV respectively.

What is XPS used for?

- Depth profiling on surfaces
- Identification and measurement of surface contamination and organic overlayers, e.g. to solve problems of adhesion of coatings on substrates
- Analysis of nanoparticles
- Silicon dioxide on silicon thickness measurement for the semiconductor industry
- Identification of counterfeit products
- Catalysis and corrosion studies
- Characterisation of a wide range of materials such as paints, polymers, ceramics and glasses
- UPS for characterisation of organic electronics

See our XPS measurement services page to find out how XPS may help with your specific application.

What are the measurement challenges?

Curved surfaces or those with topography and samples that have dimensions of the order of nanometres cause handling and quantification problems. NPL has determined correction factors that can be applied to XPS for overlayers on curved or samples of known topography and are investigating the sample preparation and characterisation of micro and nanoparticles. Quantitative organic depth profiling using XPS is also being studied. NPL is improving the depth range and accuracy of XPS by calibrating high energy XPS instruments and analysing the shape of backgrounds in an XPS spectrum.
See our Services page for more on quantitative XPS analysis.
Key Publications


'Detection limits in XPS for more than 6000 binary systems using Al and Mg K X-rays', A G Shard, Surface and Interface Analysis, 46 (3), 175-185 (2014)


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