University of Nottingham
Nanoscale and Microscale Research Centre

X-ray photoelectron spectroscopy (XPS)

X-ray photoelectron spectroscopy provides a quantitative measurement of surface (5-10 nm) elemental composition and chemical state using X-ray stimulated photoelectron emission.

Characteristic electron binding energy 'fingerprints' for a sample can be produced, allowing determination of both atomic composition and subtle chemical state variations. Elemental imaging can be formed from XPS data, and depth profiling is a powerful adjunct to quantify progressive near-surface chemistry.

Capabilities

- Quantification of surface elemental composition
- Quantification of surface chemical state, such as Fe^{2+}/Fe^{3+} or carboxyl/alcohol
- Depth profiling using an Ar gas cluster ion source
- Elemental mapping (parallel XPS imaging)

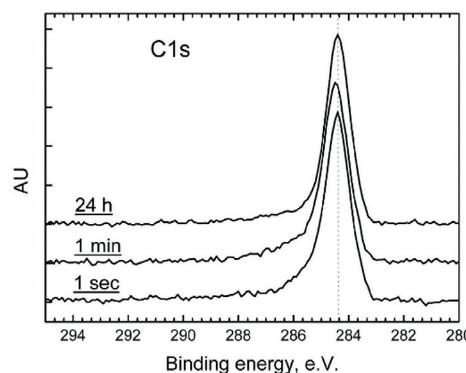
Typical applications

- Contaminant identification and quantification (stains, corrosion, residues, phase separations)
- Oxidation state analysis
- Quantification of surface chemical modifications
- Thin film thickness (up to 15 nm) and composition quantification
- Catalyst surface characterisation

Quantification and qualification of self-assembled monolayer thickness

XPS can be used to qualify and quantify surface modifications. For example high resolution XPS carbon (C1s) region scans can be used to assess alkane thiol binding to gold (Au) surfaces when prepared at different adsorption times. The quality is assessed from the C1s region, which lacks any noticeable peaks related to oxygen-containing groups or any other possible contaminations. Au Layer thickness can also be quantified from the intensity of the C-C peak compared to the Au 4f core level (not shown).

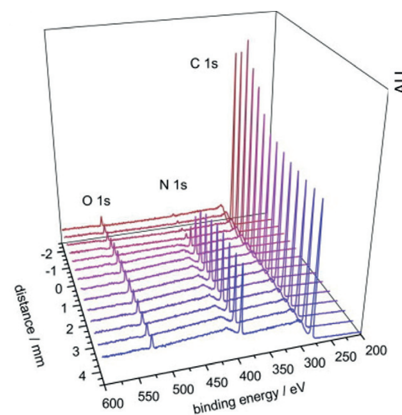
Vladimir V Korolkov, Stephanie Allen, Clive J Roberts, and Saul JB Tendler. *Journal of Physical Chemistry* 115 (2011), 14899–14906.



Quantification of chemical gradients

XPS can be used to provide characterisation of subtle differences in spatial chemical character. Here progressive (0.5mm increments) XPS widescans along a graded chemical interface are used to quantify the elemental concentration. This system is a thin hydrocarbon polymer deposited with a gradually changing thickness on a nitrogen containing polymer with uniform thickness. The gradient can be fully characterised from this information which allows the performance of this functional surface to be understood.

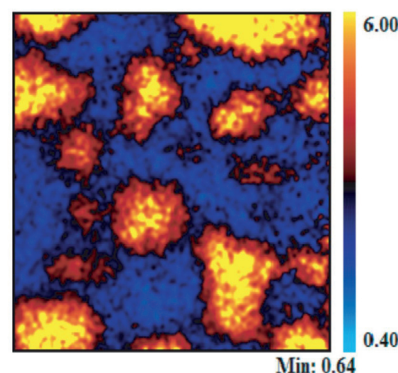
Mischa Zelzer, Ruby Majani, James W Bradley, Felicity RAJ Rose, Martyn C Davies, Morgan R Alexander. *Biomaterials* 29 (2008), 172–184.



XPS Imaging of the elemental corrosion in an optical filter

Spatially sequential XPS spectra can be processed into images to visualise elemental and chemical state distributions. This figure shows the corrosion of germanium to germanium oxide on an optical filter, as seen by XPS. An intensity map for germanium oxide (Ge 3d and O 2s) over a 400μm x 400μm area indicates significant variability incurred by moisture induced corrosion. The scale bar represents atomic %.

Emily F Smith, David Briggs, Neal Fairley. *Surface and Interface Analysis* 38 (2006), 69–75.



Our facilities

Kratos Liquid Phase Photoelectron Spectroscopy Machine (LiPPS)

- Multiple monochromated X-ray sources including Al Kα emission at 1486.6 eV, Mg, or a high energy Ag source at 2984 eV.
- Argon gas cluster source for high resolution depth profiling of organic materials (biological samples and polymers).
- High throughput multi position programmable stage allows multiple samples in one experiment including a tilt stage for topographic samples.
- Magnetic immersion lens system allows the area of analysis to be defined by apertures.
- Electrostatic/magnetic lens system (hybrid lens) and a hemispherical analyser (CHA) to sort photoelectrons according to kinetic energy.
- Electron detection and counting with a triple channel plate and delay line detector (DLD).
- Heating and cooling capabilities.
- Electrochemistry stage for in situ work on ionic liquids.

Thermo Fisher K-Alpha Photoelectron Spectrometer

- Al Kα emission X-ray source at 1486.8 eV
- Ion gun with energy range of 200-4000 eV
- 180o double focussing hemispherical analyser with 128-channel detector
- Dual beam source charge compensation
- 4-axis sample stage, 60 × 60 mm sample area, 20 mm maximum sample thickness

Find out how XPS could help with your applications, designs or solutions:

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