7.3: Imaging XPS

The combination of the features of X-ray photoelectron spectroscopy (in particular, quantitative surface elemental analysis and chemical state information - see 5.3) together with spatial localization is a particularly desirable option in surface analysis. However, whilst much progress has been made in developing the technique of imaging XPS, there is still a considerable research effort being devoted to improving the available spatial resolution beyond that which is currently available.

Different manufacturers of imaging XPS systems have adopted different strategies for obtaining spatial localization - including all of those mentioned in Section 7.1 . Specifically, these include

1. Localization by selected (limited) area analysis.
2. Localization of the probe, by focusing the incident x-rays.
3. Use of array detectors, with associated imaging optics.

1. Limited Area Analysis

The simplest approach to localising an XPS analysis is to restrict the area of the sample surface from which photoelectrons are collected using a combination of lenses and apertures in the design of the electron energy analyser. The main problem with using this approach on its own is that as the sampled area is reduced, so is the collected signal - consequently, there is a direct trade-off between spatial resolution and data collection time.

The practically achievable spatial resolution is rarely better than 100 µm. Imaging of the sample surface may then be achieved by either:

1. translating the sample position under the electron energy analyser, so that the analysed region is moved across the surface.
2. incorporating electrostatic deflection plates within the electron optics to move the region from which electrons are collected across the sample surface.

The advantage of this technique is its relative simplicity (and hence relatively low cost) - but this is reflected in the relatively poor performance!

2. Imaging XPS by X-ray Focussing

Until very recently this was not a popular option in commercial instruments, since x-rays are rather difficult to focus (compared to, for example, charged particles). Nevertheless, with recent improvements in technology, an x-ray spot size of better than 10 µm has been achieved using this approach in commercially-available instruments, and significantly better resolution than this has been achieved in specialised research instruments (see state of the art" below). Images may then be obtained *either* by scanning the sample under the focused x-ray beam, *or* by scanning the microfocused x-ray beam.

Examples of spectrometers using this technology:

- PHI Quantera XPS Microprobe

3. Array Detectors and Imaging Optics

There are a number of innovative designs for imaging spectrometers which combine array (i.e. multiple-segment) detectors with sophisticated imaging optics to obtain electron-energy resolved images at much faster acquisition rates. The spatial resolution achievable using this approach is also higher than that for either of the other techniques mentioned - state-of-the-art instruments give better than 5 µm resolution

Examples of spectrometers using this technology:

- Omicron Nanotechnology "NanoESCA"

State of the Art Imaging XPS Instrumentation

This is one area in which an ultra-high intensity x-ray source offers major advantages and the highest performance imaging XPS systems (scanning photoemission microscopes) are therefore those based at synchrotron sources. Using zone-plate technology to focus the x-rays (combined with multi-segment detectors to enhance data acquisition rates) it is possible on such systems to obtain XPS images with a resolution of better than 100 nm (see, for example, the ELETTRA ESCA microscopy web-pages).

Summary

The spatial resolution currently achievable with commercial imaging XPS instruments limit the range of potential applications - nevertheless there are many areas of materials science where the information obtainable is incredibly useful and the relatively poor spatial resolution (compared, for example, with electron microscopic techniques such as SAM) is more than offset by the benefit of concurrent chemical state definition.

Selected examples of imaging XPS data:

	Imaging XPS data from Omicron NanoTechnology (Scroll-down the thumbnails in the right-hand frame, and click on each to see an enlarged image and a description of the measurement)