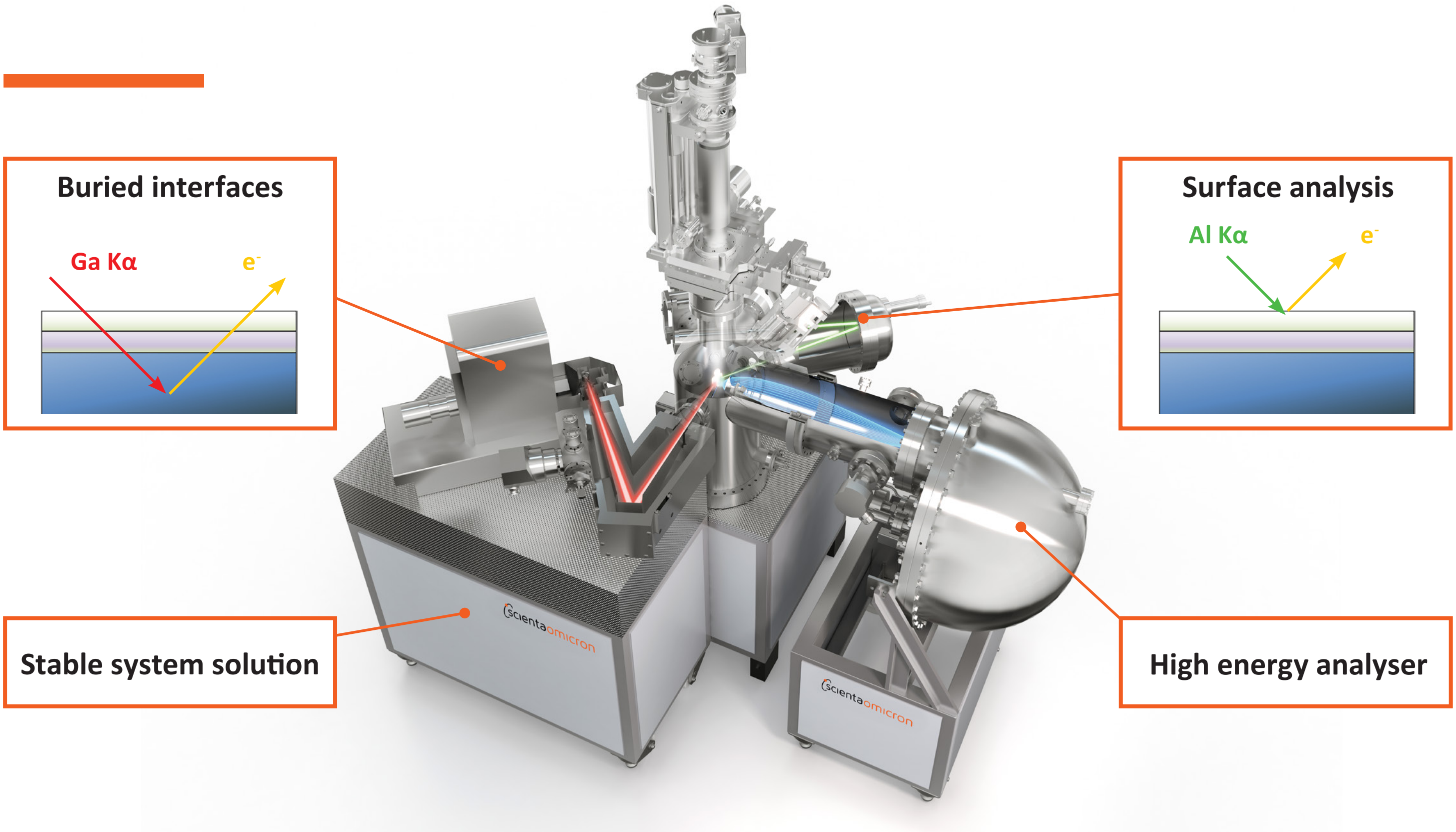
HAXPES LAB

A Window to the Bulk

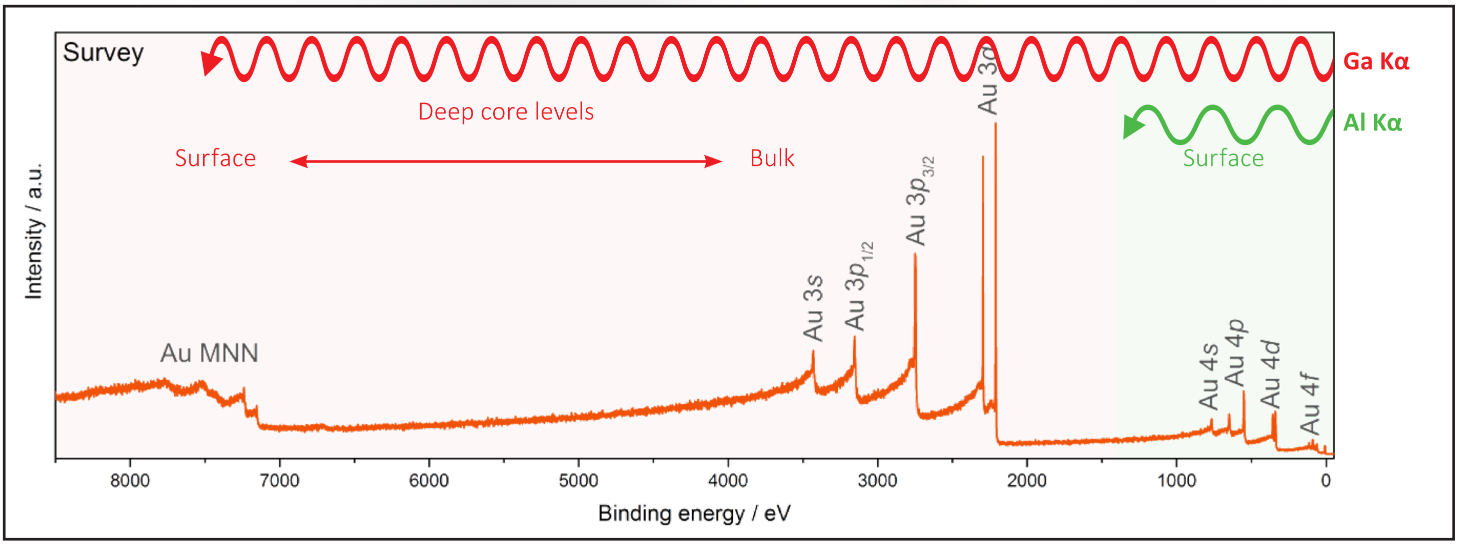


Buried interfaces

Surface analysis

Stable system solution

High energy analyser



- Robust laboratory based HAXPES solution
- Non-destructive measurements of buried interfaces
- High quality spectra with short acquisition time
- Access to chemical and electronic material properties
- 24/7 access
- Operando measurements
- Artefact-free depth profiling

HAXPES Lab - A Window to the Bulk

Scienta Omicron's HAXPES Lab brings hard X-ray photoelectron spectroscopy (HAXPES) directly to your local laboratory. With the HAXPES Lab, you can access the bulk sample properties by investigating deep core level electrons from the material, without the need for synchrotron end stations. Utilizing world class technology and expert engineering, the HAXPES Lab sets the standard for laboratory based high energy X-ray photoelectron spectroscopy.

Photoelectron spectroscopy (PES or XPS) is a well-established method for analysing wide range of material properties. While the conventional XPS instruments mainly employ soft (low energy) X-ray sources, hard X-ray photoelectron spectroscopy (HAXPES) uses high energy photons. This results in photoelectrons of higher kinetic energies (E_K) and thus greater inelastic mean free path (IMFP). Consequently, the analysis depth extends from a few nanometres of the top surface (in conventional XPS) to tens of nanometres into the bulk of the material (in HAXPES). In fact, the HAXPES Lab can combine both, soft (Al Kα) and hard X-ray source (Ga Kα), and in this way achieve combined functionality.

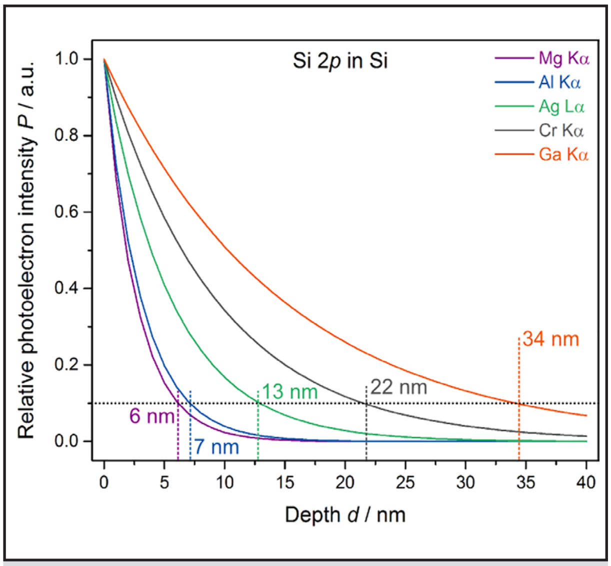
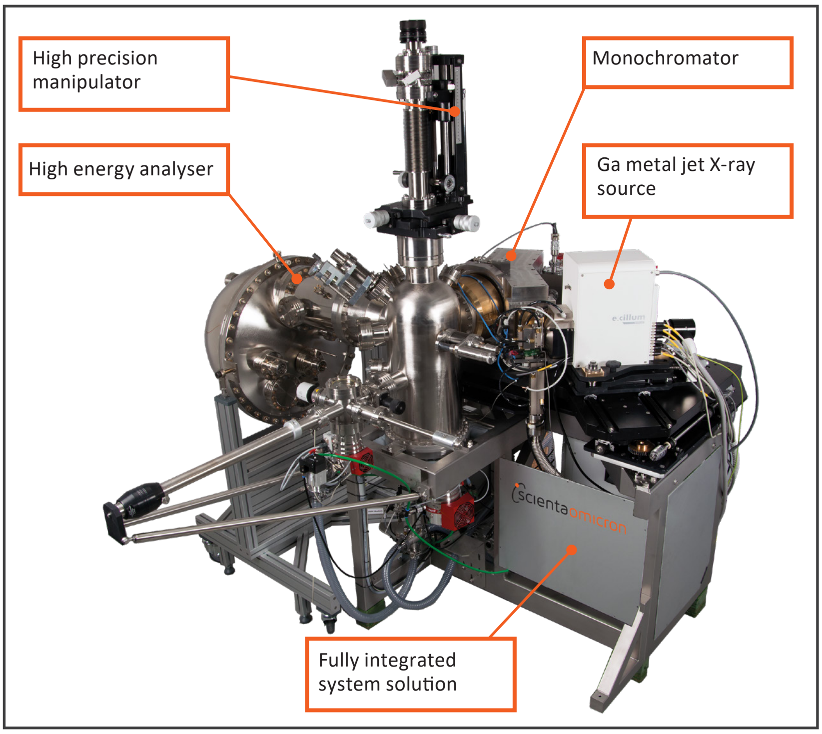


Figure 1. HAXPES using the Ga source offers 5 x greater information depth, compared to Al Kα, which also means access to buried interfaces. This provides bulk sensitivity that is unavailable using conventional XPS.



While HAXPES measurements have been successfully deployed at synchrotrons, obtaining time and access to the required endstations remains a significant challenge due to a high demand. The HAXPES Lab analytical tool solves this problem by bringing the pioneering technology directly from synchrotron to the user's laboratory. The traditional soft X-ray source along with charge neutralisation and other options is available upon request.

Superior Information Depth

A comparison between different X-ray anodes is shown in Figure 1, where the Ga liquid jet source, which is used in HAXPES Lab, shows a great advantage over other sources in terms of information depth. Additionally, the Ga metal jet source provides significantly higher flux than any alternative hard X-ray lab sources.

Benefits and Properties:

- Chemical and electronic material properties with increased information depth
- Access to buried interfaces without risk of sputter damage
- Operando investigations for electronic devices
- 24/7 access and customizable design
- Proven state-of-the-art technology

Fast and simple material development

The HAXPES Lab empowers material research and development by providing easy execution of chemical analysis of samples, without the destructive and artefact inducing surface preparation steps (e.g. sputtering). This is critical for many sensitive materials and analysis of buried interfaces such as those present in energy harvesting devices and batteries, or in coated conductive surfaces such as metal or glass. Therefore, the HAXPES Lab enables industries to leverage pioneering capabilities, this way fueling scientific progress and innovation while securing leading position in technological advancement.

Surface, bulk and artefact contributions

Having access to XPS and HAXPES X-ray sources enables measurements of different core levels (CL) of the same element, including deep CL, which are typically more sensitive to chemical shifts. After excitation, electrons with sufficient E_K escape the material and reach the detector. With an XPS source, the E_K of most elements is low, thus the obtained information is very surface sensitive. However, with high energy X-rays it is possible to be both, surface and bulk sensitive. Electrons stemming from deep core levels will have lower E_K and contain more surface sensitive information, while electrons stemming from shallow core levels will have higher E_K and contain more bulk sensitive information. This is especially valuable when detecting artefacts formed by sample exposure to different environments (e.g. air, moisture, heat, cold etc.) or by preparation steps known to induce chemical changes on the surface (e.g. sputtering). As a result, information accessed with Ga metal jet source clearly extends beyond limits of conventional XPS surface analysis and unlocks a comprehensive and effective characterisation of your materials.

Easy access to deeply buried interfaces

An example of performance of the HAXPES Lab is shown in Figure 2, where a multi-layered structure used in transistor and diode devices is investigated. The Al 1s peaks from the Al_2O_3 layer are clearly visible under 33 nm of three other oxide nanolayers (ZnO, In_2O_3 and ZrO_2). With a standard XPS instrument, it is impossible to measure this deep into similar multi-layered structures without irreversibly destroying the layers with a risk of inducing artefacts.

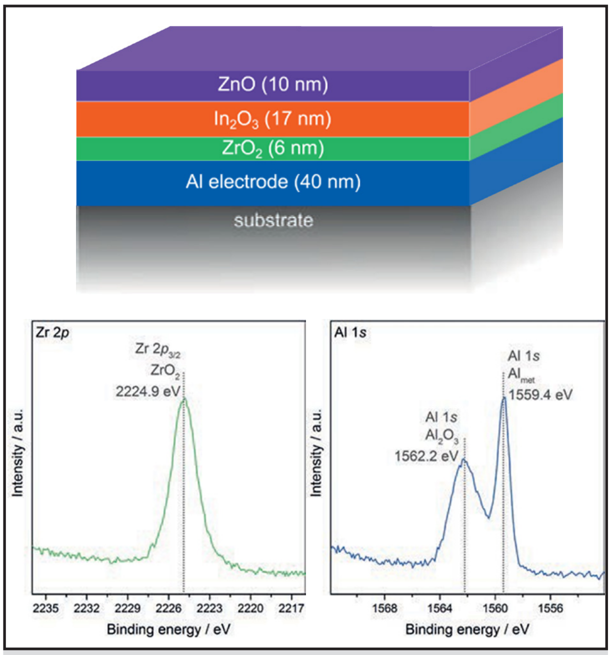


Figure 2. Buried interfaces HAXPES analysis of a transistor device. The figures show the clearly resolved Zr 2p and Al 1s peaks buried 33 nm beneath the surface.

High flux density and high energy X-ray beam

Figure 3 (a) shows a Ti 1s spectra of a single-crystal rutile sample, a common constituent of thin film semiconductor electronic devices, such as batteries and solar cells. This measurement was acquired by a HAXPES Lab in approximately 35 min, a measurement time comparable to those at synchrotron facilities. The Ti 1s spectrum shows the main peak at 4964.3 eV and a well-defined satellite feature that follows the main signal. A valence band spectrum of gold is shown in Figure 3 (b), with a distinct Fermi level. In this example, the reported energy resolution is 485 meV, which matches typical core level lifetime broadening of metals. Showing that, the HAXPES Lab system proves itself as an excellent match for most experimental applications.

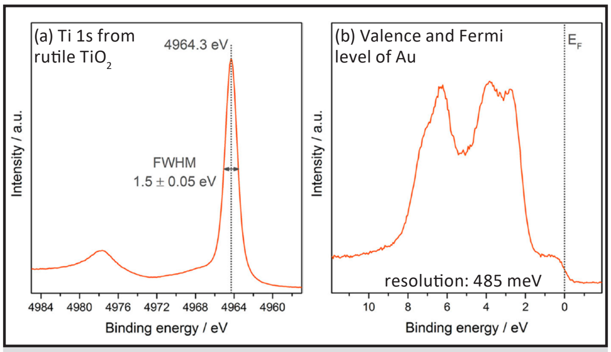


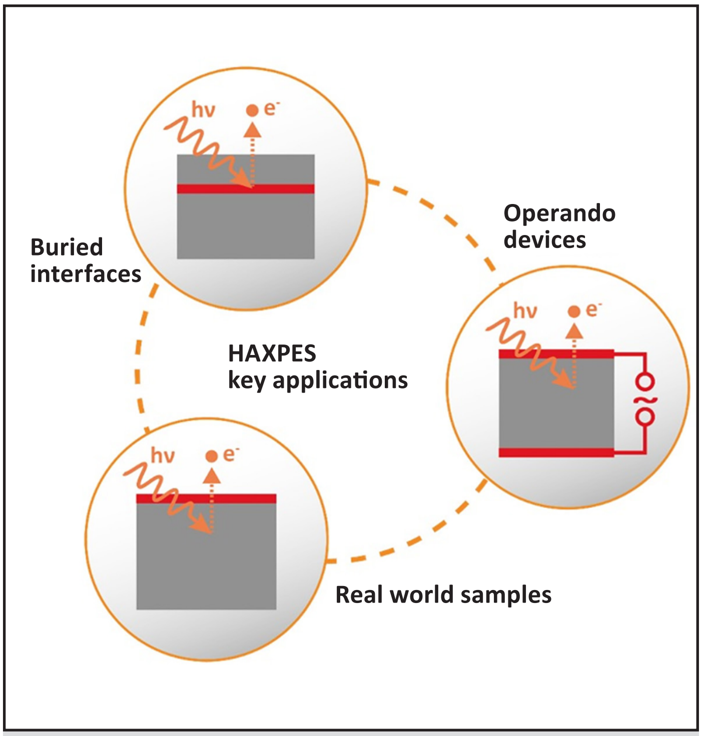
Figure 3. (a) HAXPES Lab measurement of a Ti 1s spectrum, a deep core level not accessible with a traditional XPS system. (b) Fermi edge of Au showing total instrument resolution under 0.5 eV.

Shifted Auger transitions

Transition metals are known to have many Auger transitions which often complicate the XPS spectra, as Auger and core level peaks often overlap. By using HAXPES, the constant E_K Auger transitions are shifted to different binding energy positions. As a result, the overlap with important core levels is not an issue and the spectral analysis becomes more straightforward.

Diverse applications

The HAXPES Lab is a versatile tool with a wide application range. Over the years it has proven invaluable in research of semiconductor materials in thin film electronic devices including the operando characterization of bias induced changes in chemical composition of material interfaces. Other known applications include polymer materials, metal surfaces and coatings, or even food processing and pharmaceutical industry. Whether collecting data, optimising production processes, or analysing evidence, the HAXPES Lab excels in providing high resolution, artefact-free, comprehensive results that will lead you to fast material advancement.



HAXPES key applications

Technical Data

HAXPES Lab

X-ray source:	Excillum Ga Kα metal jet
Excitation energy:	9.25 keV
Spot size:	50 µm
Maximum power:	250 W
Total system resolution:	< 0.5 eV
Base pressure:	5×10^{-10} mbar
Heating options	PBN, electron beam, HT
Lens modes:	Transmission, angular
Software:	PEAK, MISTRAL

EW4000 analyser

Energy resolution:	< 100 meV at 100 eV E_{pass} and 10 keV $E_{kinetic}$
Transmission mode lens acceptance angle:	±30°
Angular modes:	± 30°, ± 28°, ± 22°
Transmission mode kinetic energy range:	100 – 10 000 eV (standard) 5 – 100 eV (with UPS mode extension)
Angular mode kinetic energy range:	100 – 10 000 eV
Pass energy:	20, 50, 100, 200, 300, and 500 eV (and 2, 5, and 10 eV with UPS upgrade)
Working distance:	40 mm
Slits:	9
Detector type:	MCP, 2D camera detector
Acquisition mode:	Scan (swept), fixed
Detector modes:	Pulsed, ADC
Bakeout temperature:	Up to 150°C

Other options and upgrades:	Bias, sputtering, heating, glovebox extension, preparation chamber, gas cluster ion beam source, flood source, Al Kα source

How to contact us:

Europe and other regions:
info@scientaomicron.com

North America:
sales-NA@scientaomicron.com

China:
sales-CN@scientaomicron.com

Japan:
sales-JP@scientaomicron.com

or please visit
www.ScientaOmicron.com
for more information.

© Scienta Omicron ■ HAXPES Lab (SO Brochure/2023) ■ Specifications and descriptions contained in this brochure are subject to change without notice.