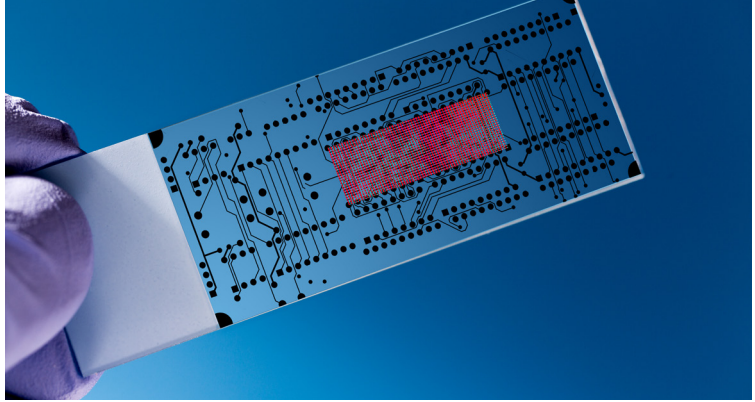
PHYSICAL ELECTRONICS
A DIVISION OF ULVAC-PHI

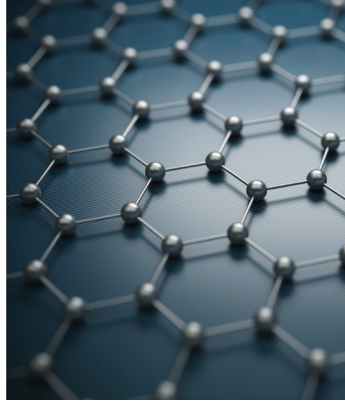
PHI

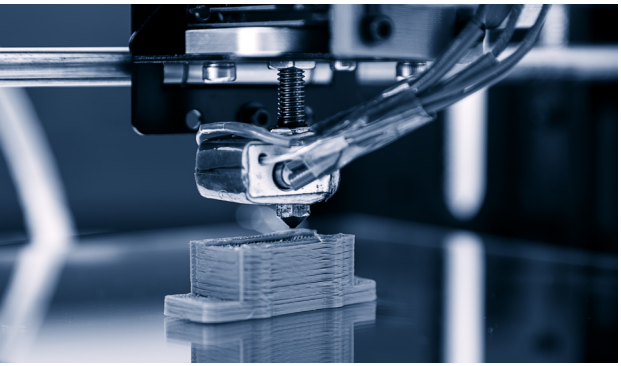
Quantes

Scanning XPS/HAXPES Microprobe


PROTECTIVE GLASS
N-TYPE SILICON
P-TYPE SILICON
CONDUCTIVE METAL BASE





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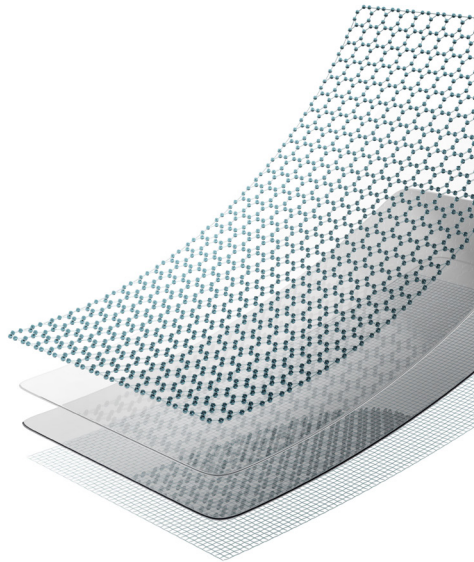
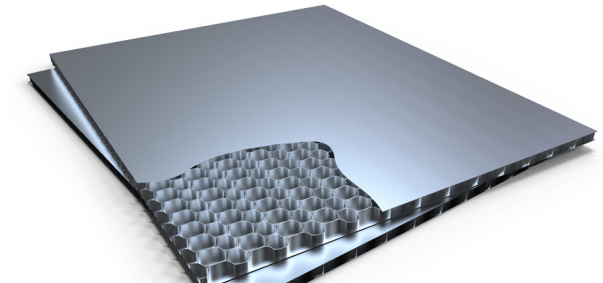
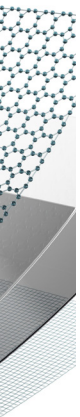






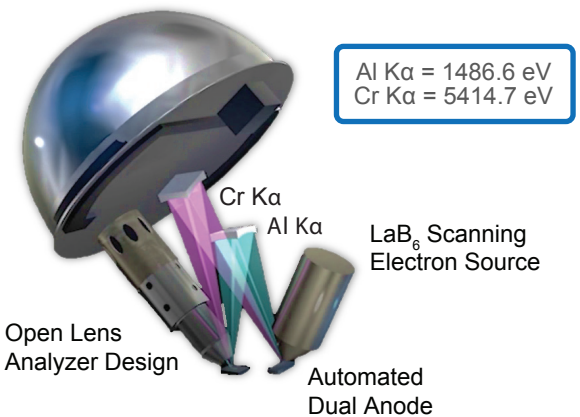
PHI *Quantes*

Scanning XPS/HAXPES Microprobe

The PHI *Quantes* is the only automated, high-throughput lab-based HAXPES spectrometer on the market. It is a unique scanning X-ray photoelectron microprobe that combines a high energy (HAXPES) monochromatic X-ray source (Chromium Kα) with a conventional monochromatic soft X-ray source (Aluminum Kα). Both sources are high flux focused X-ray beams that can be scanned across the sample surface and can be used to define analysis points, areas, lines, and maps with 100% confidence.

The analytical information depth using the Cr source is about 3 times deeper than with the Al source. This opens opportunities for probing thicker film structures and buried interfaces, as well as minimizing the effects of surface contamination and ion-induced chemical damage during depth profiling.

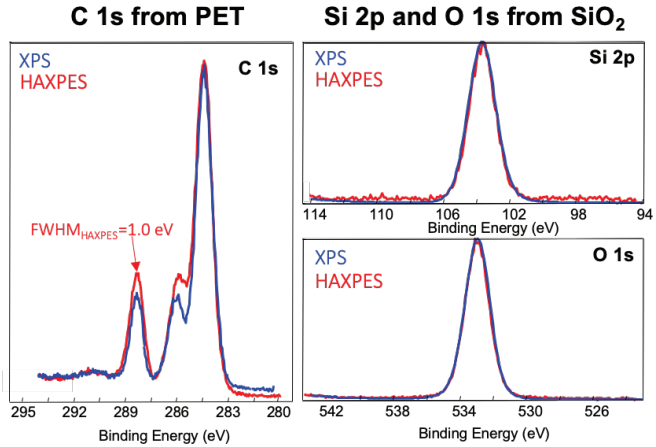
Bring HAXPES synchrotron capabilites into your lab with the PHI *Quantes*!



LAB-BASED HAXPES

Benefits over Synchrotron HAXPES

- Efficient charge neutralization for insulating and semiconducting samples
- Quantification of detected species
- Fast screening tool for experiment development before time and cost-intensive synchrotron beam line testing
- Full automation of sample manipulation and data acquisition
- Fully versatile and robust X-ray spectrometer using both soft and hard X-ray sources
- Full automation of switching between Al and Cr sources (approximately 1 minute switchover time)
- High throughput spectrometer with all data acquisition capabilities for both X-ray sources
- Large sample mount with 2 additional parking positions



Effective Charge Neutralization of insulators

Efficient charge neutralization: left - high resolution C 1s from PET shows excellent chemical state separation using both sources; right – XPS and HAXPES Si 2p and O 1s overlaid showing symmetrical shape and similar width of spectra.

	SiO_2				PTFE	
	Si 2p	O 1s	Si 1s	O 1s	C 1s	F 1s
Theory	33.3	66.7	33.3	66.7	33.3	66.7
Cr source, average	**33.7**	**66.3**	**34.1**	**65.9**	**33.0**	**67.0**

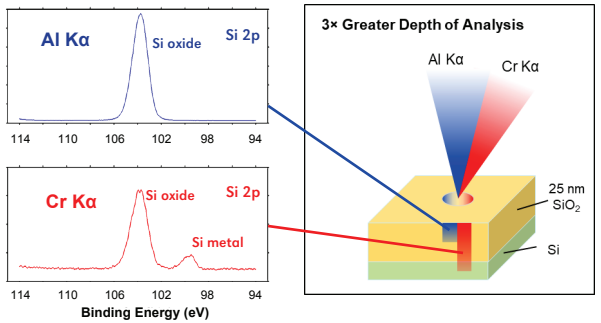
	TiO_2			
	Ti 2p	O 1s	Ti 1s	O 1s
Theory	33.3	66.7	33.3	66.7
Cr source, average	**33.8**	**66.2**	**33.9**	**66.1**

Excellent Quantification

Quantification using theoretical relative sensitivity factors for reference bulk materials using low and high binding energy transitions.

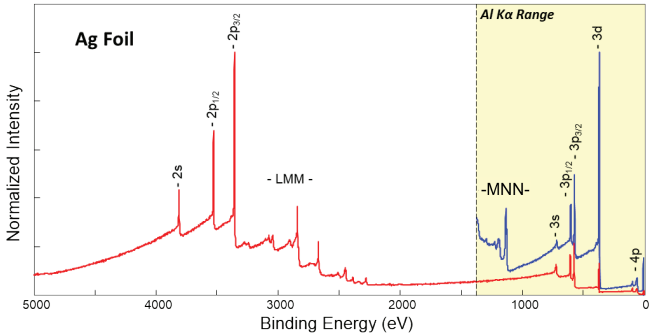
BENEFITS OF A HARD X-RAY SOURCE

Different Depths of Analysis with XPS and HAXPES



Si 2p high-resolution spectra obtained using Al and Cr sources from 25 nm SiO_2/Si sample. Signal from Si metal substrate is detected in spectrum obtained using Cr source due to larger information depth with respect to Al source.

Additional transitions using HAXPES



Overlaid survey spectra of Ag foil collected with Al and Cr X-rays. Due to the higher photon energy of Cr X-rays, multiple higher binding energy transitions become available.

The Cr X-ray source has a photon energy of 5414.7 eV and provides for depths of analysis roughly 3 times those obtained using an Al X-ray source. This allows for:

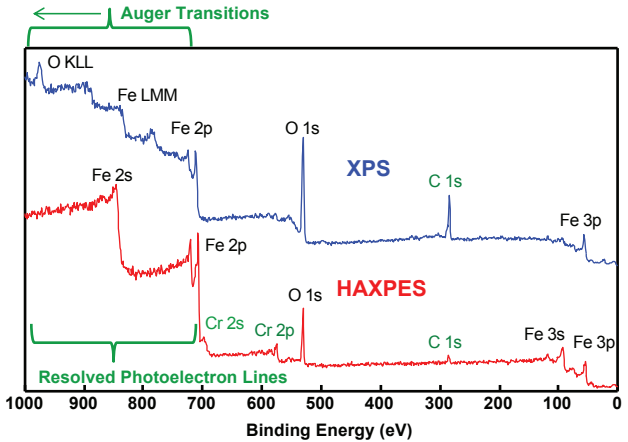
- Analysis of buried layers and interfaces deeper than traditional XPS
- Decreased effect of chemical state damage induced by ion sputtering
- Access to additional transitions of higher binding energy for complementary chemical information and interpretation
- Reduce effect of surface contamination

BENEFITS OF COMBINING XPS WITH HAXPES

- Collecting spectra from the same sample using both Al Kα and Cr Kα X-ray sources demonstrates the ability to shift Auger transitions and clearly resolve overlapped photoelectron lines.

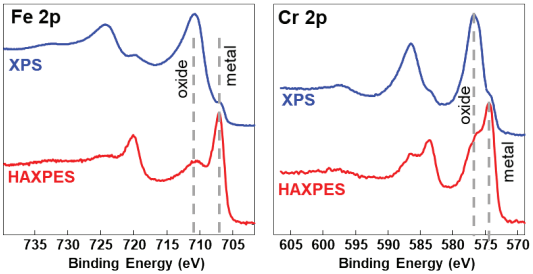
- HAXPES is much less surface sensitive than XPS, reducing the need to clean adventitious contamination prior to analysis.

- Chemical information from both surface (XPS) and near-surface (HAXPES) depths can be obtained without ion beam sputtering.



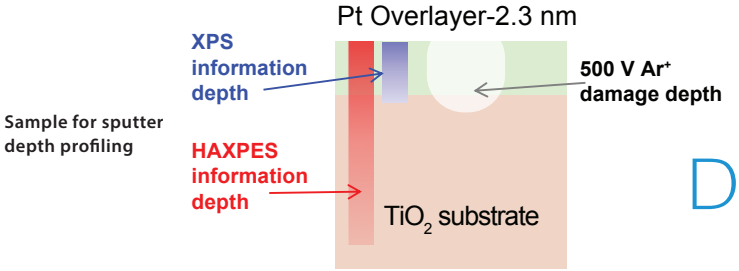
Elimination of Auger Peak Interferences and Reduction in Effect of Surface Contamination

In the survey spectrum obtained from stainless steel sample with the Al X-ray (blue trace), the Fe and O Auger transitions overlap with photoelectron lines. Using the Cr X-ray source (red trace) the Auger peaks are shifted and the photoelectron lines can be resolved. Of note: the C 1s peak in survey spectrum is much smaller when obtained using Cr X-ray source.

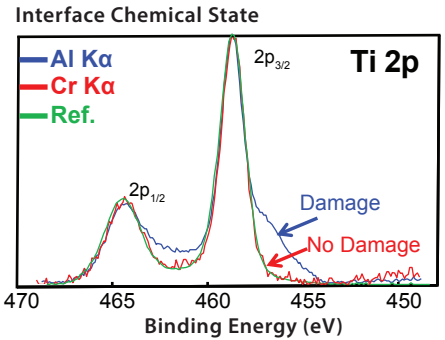


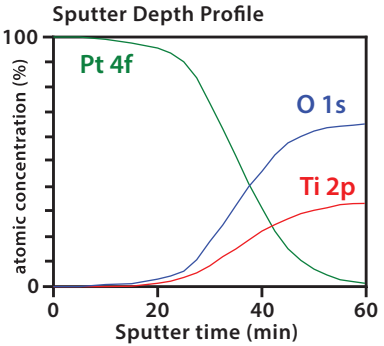
More complete Characterization of Surface Oxidation

High resolution Fe 2p and Cr 2p spectra using Al (blue) and Cr (red) X-ray sources showing oxidation at the surface and a mixture of oxides and metals at deeper depths.



ELIMINATION OF CHEMICAL STATE DAMAGE AT INTERFACES





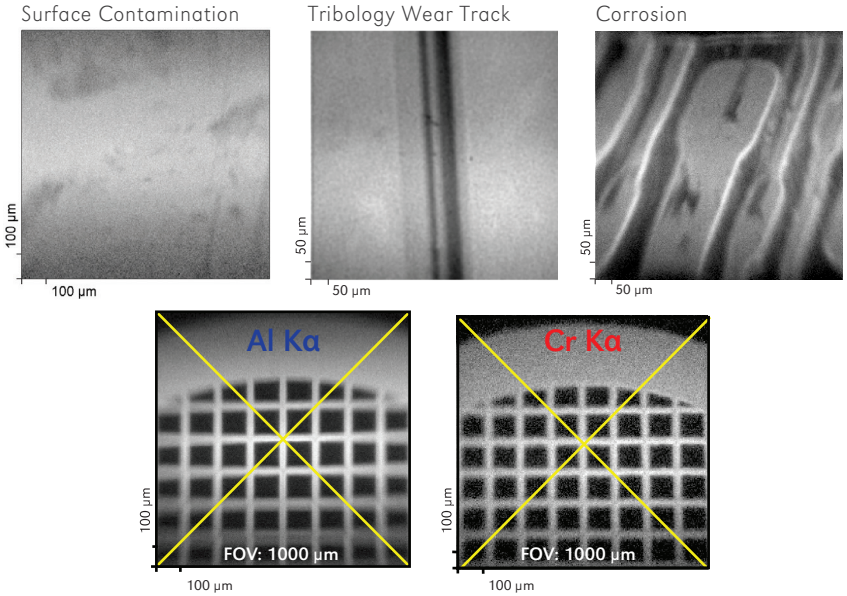
Depth profile through Pt overlayer using 500 eV Ar^+. The Ti oxide spectrum obtained using the Al source shows clear damage, while the Ti oxide spectrum using the Cr source shows no sign of damage.

- Using the Cr X-ray source, quantitative depth profiles can be reliably obtained from ion-beam sensitive materials.
- Deeper sampling depth using the Cr source allows to probe beyond the depth of possible damage induced by ion sputtering.
- Combination of Al and Cr data in depth profiles provides information on extent of damage.

SEM-LIKE XPS/HAXPES MICROPROBE

PHI *Quantes* is used much like an SEM when characterizing non-homogeneous materials. Secondary electron images (SXIs) using either the Al or Cr source enable analysis points or areas to be quickly located and analyzed. SXI images can be acquired within seconds for Al and 1-2 minutes for the Cr source. The use of the same optics for SXIs and photoelectron analysis guarantees that spectroscopic data is collected from the selected feature of interest. This unique capability facilitates the rapid and confident location of small sample features for analysis.

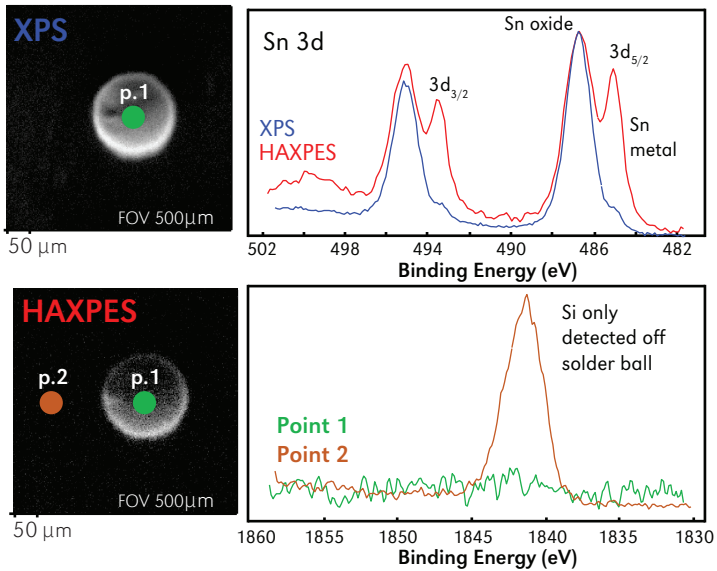
X-ray Induced Secondary Electron Images (SXI)



Similar to operating an SEM/EDS, X-ray induced secondary electron images (SXIs) are used on the PHI *Quantes* for real-time location of features of interest and to select points/areas of analysis. The focused Al or Cr X-ray beam can be used to define single or multiple analysis points, areas, lines, and maps.

HIGH PERFORMANCE LARGE AND SMALL AREA SPECTROSCOPY

Small Area XPS and HAXPES Characterization



Using the SXI, an analysis point is defined on the solder ball and is analyzed with a 20 µm diameter Cr or Al Kα X-ray beam. The HAXPES data shows a higher percentage of metallic Sn than the XPS data and no Si detected on the solder ball. This is consistent with the formation of surface oxides on the solder ball. Efficient charge neutralization for micro-analysis is observed.

- The X-ray source is tunable from sub-10 µm for Al Kα and 14 µm for Cr Kα to 200 µm diameter. When combined with the open-lens analyzer design, detection efficiency is maximized and X-ray dose for analysis is minimized.

- Both X-ray sources are aligned to the same focal point of the electron energy analyzer, enabling same area analysis using either XPS or HAXPES, thus providing chemical information from small or large areas at different sample depths.

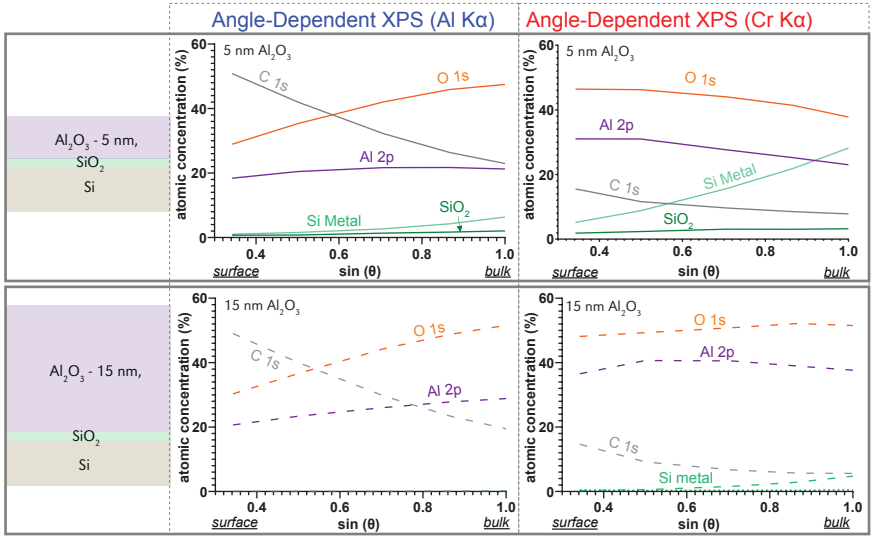
- This unique instrument also provides high-performance large area analysis capability. Large area analysis is achieved using a mode analogous to a rotating anode, providing high sensitivity and high energy resolution for analysis areas up to 1.4 mm wide.

THIN FILM NON-DESTRUCTIVE DEPTH PROFILE ANALYSIS

- Angle-dependent measurements using both X-ray sources are fully automated for non-sputter depth profile analysis of thin films.

- AD-HAXPES probes thicker layers and minimizes the influence of carbon contamination overlayer on angular profiles.

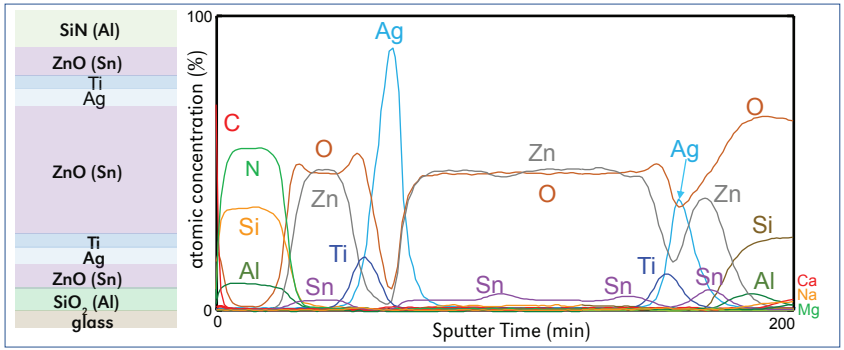
AD-HAXPES Probes Thicker Layered Structures



Angle-dependent profile of 5 nm and 15 nm thick $Al_2O_3/SiO_2/Si$ by Al Kα and Cr Kα. Profiles measured with Al Kα are similar to each other, due to the shallow depth of analysis. Profiles measured using Cr Kα are markedly different from each other, since the increased depth of analysis of Cr Kα allows for the analysis of the complete layer structure.

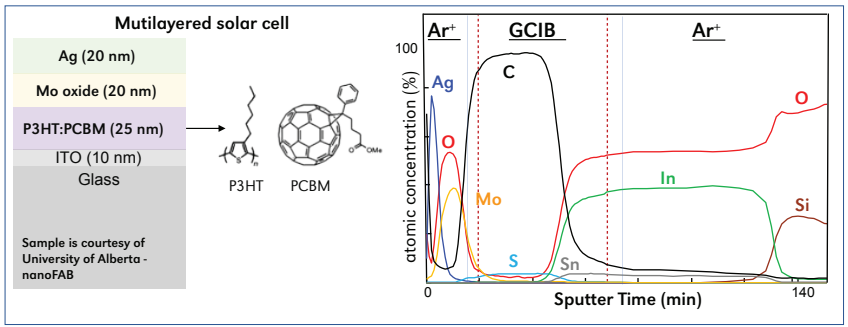
THIN FILM DEPTH PROFILE ANALYSIS

Flexibility of Monoatomic Ar Parameters



500 eV Ar^+ depth profile from a multilayered coating on glass. The energy of monoatomic Ar can vary between 350 eV and 5kV.

Mixed Organic/Inorganic Layer Depth Profiling



Multilayered solar cell with both organic and inorganic layers on glass. Switching between 1 keV Ar^+ and GCIB sputter beams allows fast profiling through >300 nm of mixed material, preserving the chemistry of the organic layer.

- Dual micro-focused X-ray sources, automated dual beam charge neutralization, compucentric Zalar rotation, multi-point micro-area depth profiling within a single crater and advanced data reduction algorithms provide the highest performance XPS depth profiling capability available.

- Low voltage monoatomic Ar is efficient for depth profiling of ultra thin films and multilayered structures.

- Optional Gas Cluster Ion Beam (GCIB) extends application of depth profiling to organic materials as well as for efficient cleaning of surface contamination. Depth profiling using the Cr X-ray source provides damage-free interface and buried layer analysis.

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Standard Features

- XPS/HAXPES microprobe with ≤ 7.5 µm spatial resolution for Al X-rays and <14 µm for Cr X-rays
- High sensitivity electrostatic detection optics
- Dual beam charge neutralization
- Robotic sample handling
- Automated 5-axis stage
- Two internal sample parking stations
- Accepts samples up to 100 mm in diameter and 25 mm thick
- High performance floating column Ar ion gun
- High speed snapshot depth profiling mode
- Multipoint depth profiling within a single crater
- Quantitative chemical state mapping
- Automated angle dependent profiles

Optional Accessories

- Sample Positioning Station
- Dedicated turbo pump for Ar ion gun
- Hot/Cold sample intro stage
- 4-contact sample stage
- Auxiliary chamber for sample transfer to/from external instruments and glove boxes
- Dual in situ monoatomic/GCIB sputtering gun
- Glove box adapter for introduction chamber