PHYSICAL ELECTRONICS
A DIVISION OF ULVAC-PHI

PHI 700Xi

Scanning Auger Nanoprobe

SCANNING AUGER

Nanoprobe

Sub-nanometer surface sensitivity

6 nm secondary electron image resolution

Coaxial electron gun and analyzer geometry

Superior Auger imaging capability

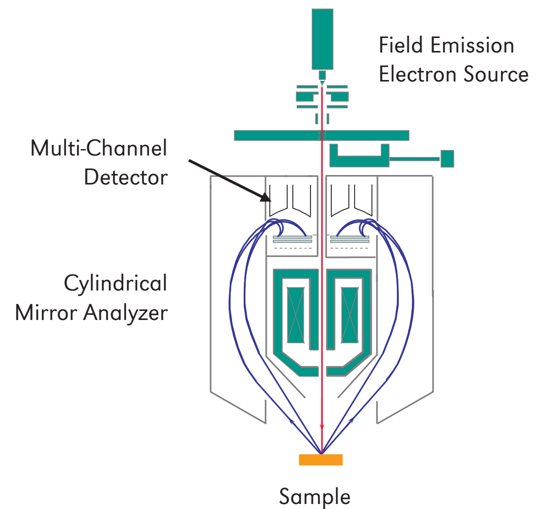
Highest performance Auger sputter depth profiling

High productivity instrument platform

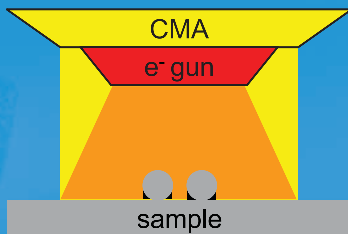
A SUPERIOR SCANNING AUGER NANOPROBE FROM THE RECOGNIZED WORLD LEADER

The PHI *700Xi* Scanning Auger Nanoprobe is a unique, high performance Auger Electron Spectroscopy (AES) instrument that provides elemental and chemical state information from sample surfaces and nano-scale features, thin films, and interfaces. Designed as a high performance Auger Nanoprobe, not an SEM with Auger capabilities, the PHI *700Xi* provides the superior Auger imaging performance, spatial resolution, sensitivity, and spectral energy resolution needed to address your most demanding AES applications.

Coaxial Geometry



COAXIAL ANALYZER / ELECTRON GUN GEOMETRY



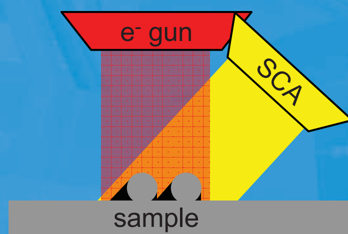
Secondary electron image

Ni Auger map

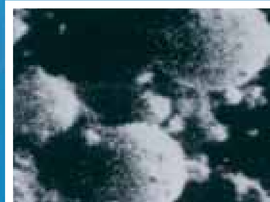
In Auger map

PHI's coaxial electron gun and analyzer geometry provides the sensitivity and unobstructed vision needed to fully characterize the microstructures that exist on most real world samples. In this example, Auger data is obtained from all sides of the particles and between the particles with equally high sensitivity.

NON-COAXIAL ANALYZER / ELECTRON GUN GEOMETRY



Secondary electron image



Ni Auger map

In Auger map

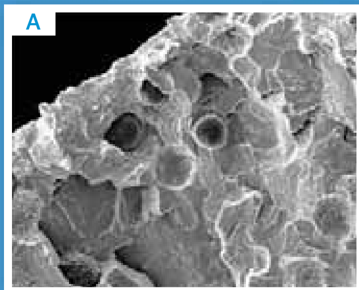
Instruments with non-coaxial geometry suffer from geometric effects that dramatically reduce instrumental sensitivity and even create shadows that prevent any analysis in some locations. In this example, high sensitivity is only observed on areas of the particles that face the analyzer, while the back side of the particles and the areas between the particles are inaccessible because of analyzer shadowing that occurs in an instrument with non-coaxial geometry.

Auger Mapping

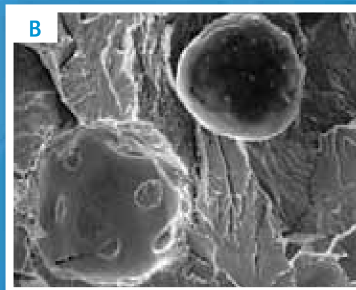
A COMPLETE COMPOSITIONAL PICTURE

The coaxial analyzer and electron gun geometry provided by the PHI *700Xi* produces a complete compositional picture of the area selected for analysis. The analyzer will provide data from every location the electron gun probes. Black areas in maps are usually not caused by sample roughness and analyzer shadowing, but instead indicate the presence of another element.

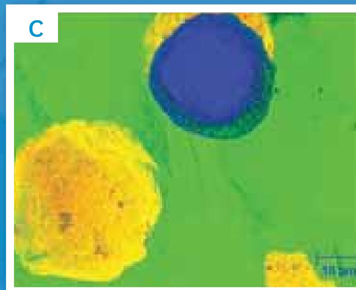
MATERIALS CHARACTERIZATION



Secondary electron image



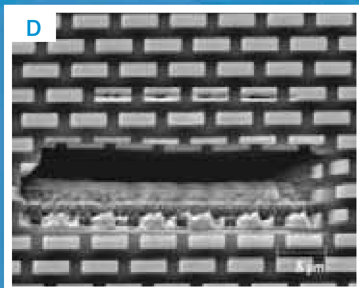
Secondary electron image



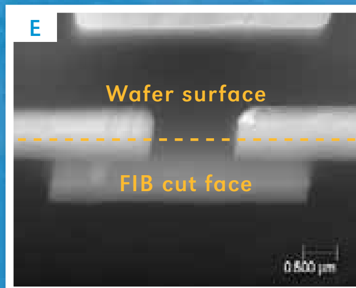
Auger maps Fe (green), C (blue), and Sn (yellow)

The secondary electron images in figures A and B show the microstructure of a ductile iron fracture surface including graphite nodules and craters where graphite nodules have fallen out as a result of the fracture. The AES maps in figure C show the ability to map across the graphite nodule and the crater where Sn has segregated to the nodule / iron interface. Only PHI Auger instruments with coaxial electron gun and analyzer geometry provide such a complete compositional picture of a rough sample surface.

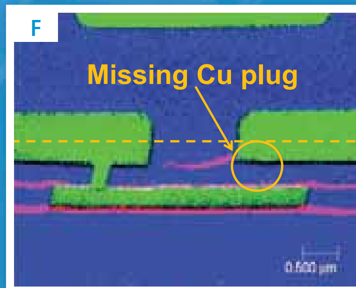
FIB CUTS



Secondary electron image



Secondary electron image



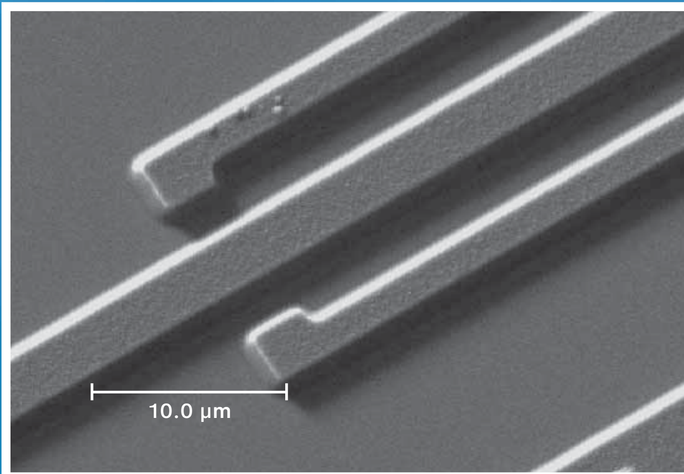
Auger maps Si (blue), Cu (green), and N (red)

Focused Ion Beam (FIB) cuts are routinely used in the semiconductor industry to characterize buried defects and device structures. The coaxial geometry of PHI Auger instruments provides high sensitivity over a broad range of emission angles which allows spectral data and maps to be obtained from FIB cuts with uniform and high sensitivity across the face of the cut. Images D, E, and F above, show that a Cu plug (interconnect) is missing and the cause of an electrical open circuit in the device.

Thin Film Analysis

SUPERIOR THIN FILM ANALYSIS

The PHI *700Xi*'s floating column ion gun provides a broad range of depth profiling capabilities. At higher ion beam energies (2-5 keV) structures several microns thick can be routinely depth profiled. For thin and ultra thin films (< 5 nm) the floating ion column can be used to efficiently sputter with ion beam energies of 100-500 eV. The use of lower accelerating voltages reduces sputter mixing that could broaden the detected interfaces in an ultra thin film structure.



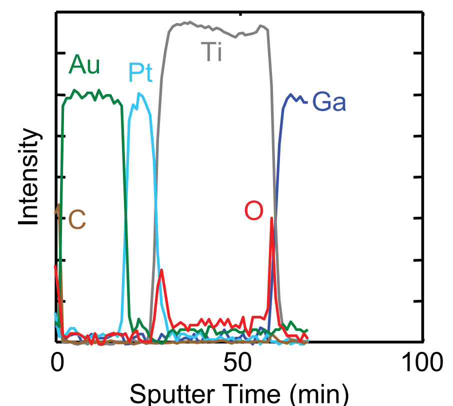
Secondary electron image of 2 µm lines

Ion beam induced sample roughening degrades the depth resolution of many thin film sputter depth profiles. To minimize this effect, the sample can be rotated during the sputtering process (Zalar Rotation™). The PHI *700Xi*'s precision sample stage can be used under computer control to define a specific sample feature as the center of rotation (Compucentric Zalar Rotation).

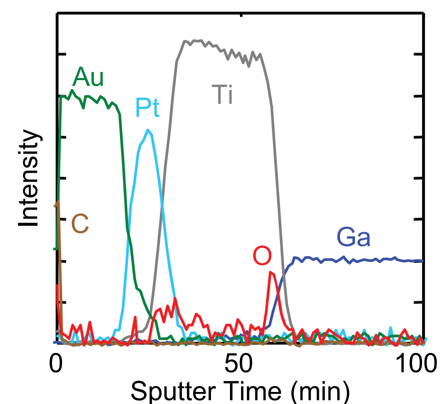
The precision with which Compucentric Zalar Rotation can be accomplished in the PHI *700Xi* allows small features, such as the 2 µm wide metal line shown here, to be sputter depth profiled with Zalar Rotation and remain at the desired location throughout the analysis.

Depth profiles collected with and without Zalar Rotation from the 2 µm wide metal line clearly show enhanced interface sharpness and an improved ability to detect the interfacial oxygen contamination when using Zalar Rotation.

With Zalar Rotation



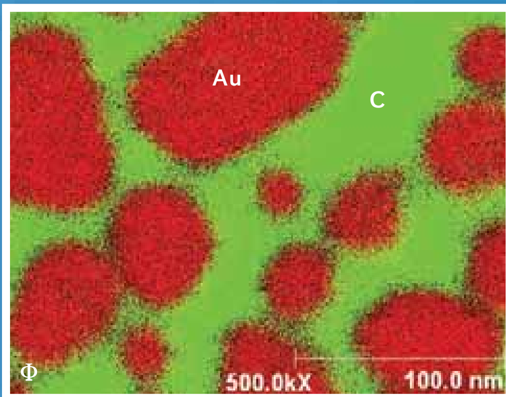
Without Zalar Rotation



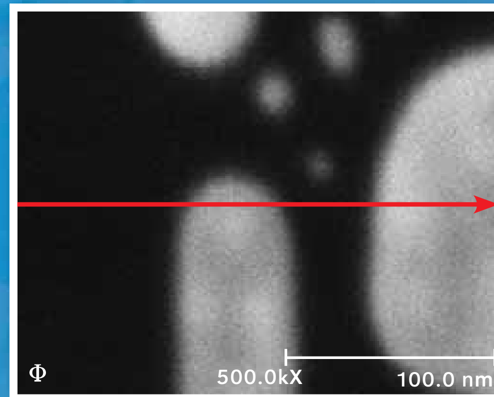
Spatial Resolution

HIGH STABILITY NANOSCALE ANALYSIS PLATFORM

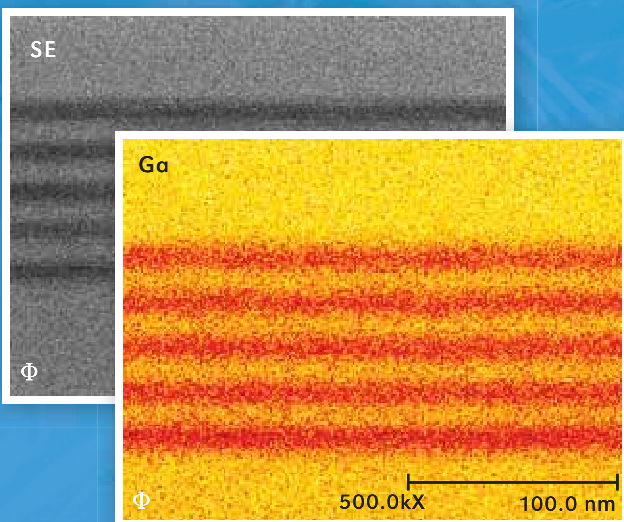
High performance electron optics, precision sample handling, and advanced vibration and thermal isolation provide a superior environment for nano-scale Auger imaging and analysis at working magnifications of 500,000 X and higher.



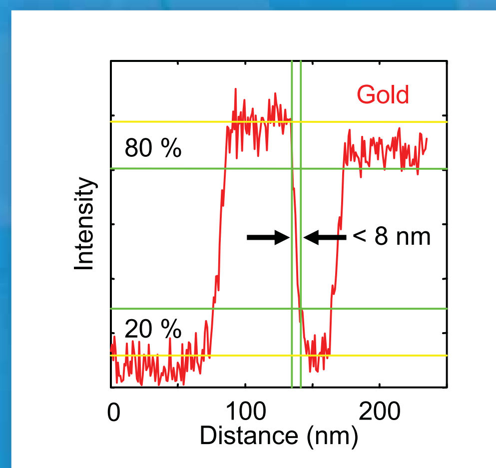
Auger Maps, of a gold on graphite spatial resolution standard, obtained with a 20 kV – 1 nA electron beam at an original magnification of 500,000 X



Secondary electron image of a gold on graphite spatial resolution standard at an original magnification of 500,000 X



Secondary electron image and Ga Auger map of a 10 nm GaAs/AlAs super lattice structure obtained at an original magnification of 500,000 X

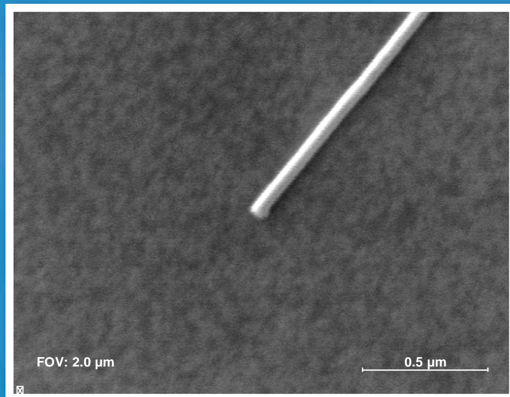


Auger spatial resolution measured from a gold line scan on the gold/graphite spatial resolution standard obtained with a 20 kV - 1 nA electron beam

Surface Sensitivity

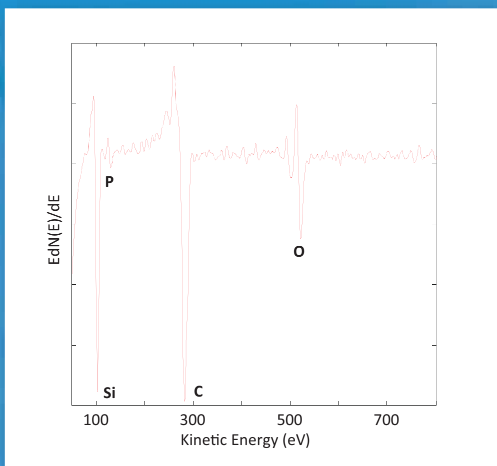
SUB-NANOMETER SURFACE SENSITIVITY

The sub-nanometer surface sensitivity provided by the PHI *700Xi* Nanoprobe enables the ability to observe and characterize ultra thin surface layers that are difficult or impossible to detect with SEM-EDS, TEM-EELS, or Atom Probe tomography.

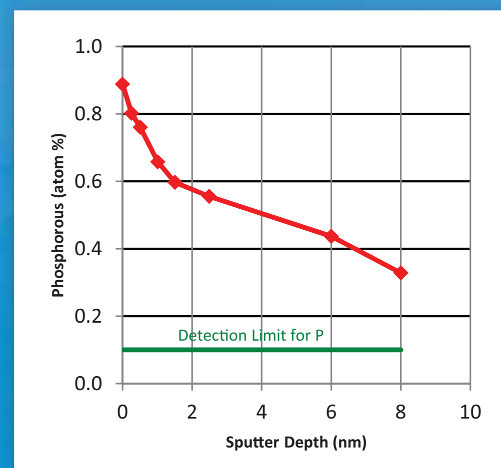


Secondary electron image of a silicon nanowire.

Surface composition often plays a critical role in the performance of a material. In the example shown on this page a phosphorous doped silicon nanowire was characterized to determine the distribution of phosphorous along the length of the nanowire and radially into the nanowire as a function of depth. The sputter depth profile results shown below indicate phosphorous has segregated to the outer surface of the nanowire and that the detection limit for the conditions used is 0.1 atom percent for phosphorous.



Auger spectrum showing the presence of phosphorous on the surface of the nanowire.

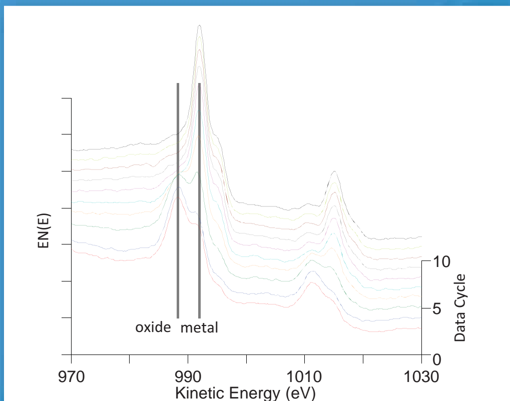


Sputter Depth Profile showing a phosphorous rich surface on the silicon nanowire.

Surface Chemistry

HIGH ENERGY RESOLUTION

The PHI *700Xi* is equipped with a high energy resolution mode of operation for use when normal mode spectra do not provide the energy resolution needed to observe a chemical change. This unique capability does not interfere with the superior imaging capabilities of the PHI *700Xi*.

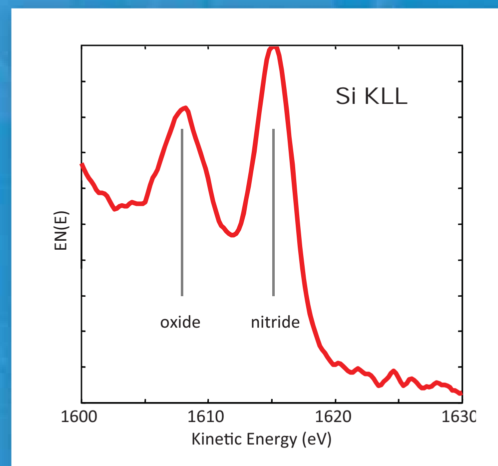


High energy resolution sputter depth profile of a surface oxide film on a Zn surface.

Secondary electron image of a silicon nanocone.

When it is difficult to observe chemical shift information in the normal analysis mode (analyzer resolution 0.5%), the high energy resolution mode (0.1%) can be used to increase chemical sensitivity. Shown above are high energy resolution Zn LMM spectra from a sputter depth profile into a Zn metal surface. From this data it is possible to detect and measure the thickness of a surface oxide film.

Shown to the right is a secondary electron image of a silicon nanocone and a high resolution Si KLL spectrum from the surface of the base of the nanocone. In addition to the expected native oxide, silicon nitride is detected on the surface of the nanocone. The gasses used to grow the nanocone contained N.

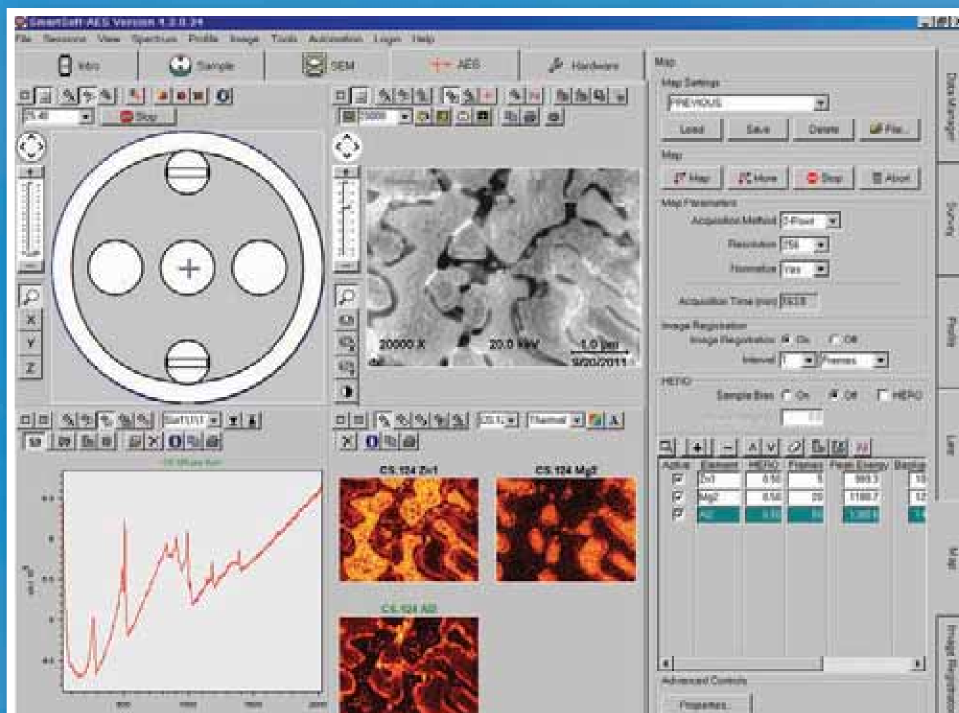


High energy resolution spectra from the surface of a silicon nanocone.

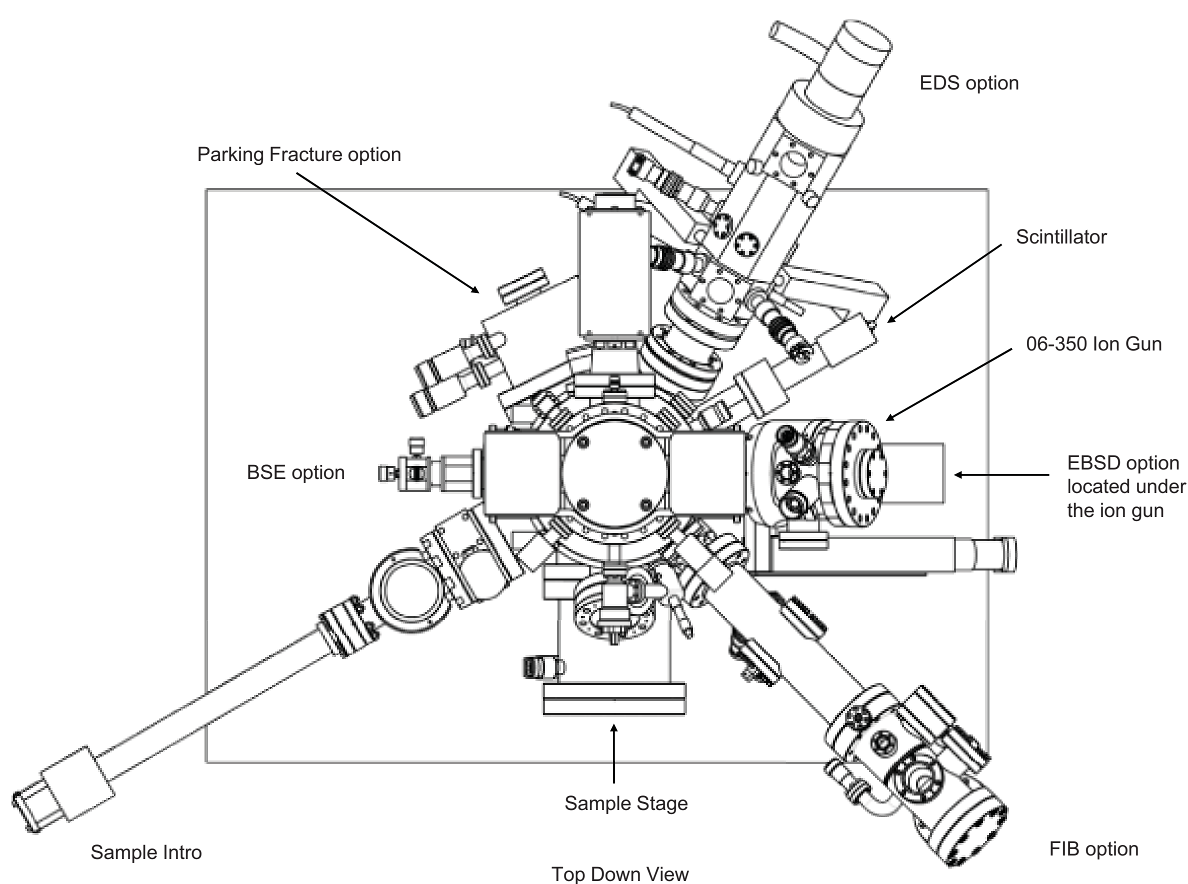
SmartSoft

PHI'S NEXT GENERATION USER INTERFACE

SmartSoft displays a single full screen window with five session tabs focused on key instrument tasks: Sample Introduction, Sample Navigation, SEM Imaging, Data Collection, and Sputtering. Each session provides convenient access to sub-task tabs located on the right side of the window. SmartSoft provides a fully integrated, task oriented user interface for managing all hardware and analysis capabilities provided by the PHI *700Xi* Auger Nanoprobe.



PHI SmartSoft analysis (AES) session with the Map tab selected. In a single full screen window: sample information, SEM image, spectra, and maps are conveniently displayed.



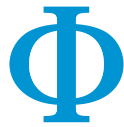
Features and Accessories

PHI *700Xi* FEATURES INCLUDE:

- 6 nm SE image resolution at Auger analysis position
- 8 nm Auger resolution with high sensitivity
- Superior vibration and thermal isolation
- Coaxial electron gun and analyzer geometry
- Floating column ion gun for low voltage sputtering
- Low energy ion beam assisted charge neutralization
- Precision, motorized sample stage
- Automated multi-sample analysis
- Compucentric Zalar Rotation
- PC with Microsoft Windows operating system
- PHI SmartSoft instrument control software
- PHI MultiPak data reduction software

OPTIONAL ACCESSORIES:

- Die navigation software
- In situ sample parking
- In situ sample fracture apparatus
- EDS Detector
- EBSD Detector
- BSE Detector
- FIB



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A DIVISION OF ULVAC-PHI

About PHI

EXPANDING SURFACE ANALYSIS THROUGH INNOVATION

Physical Electronics (PHI) is a subsidiary of ULVAC-PHI, the world's leading supplier of surface analysis instrumentation. PHI's innovative XPS, AES, and SIMS technologies provide our customers with powerful tools to solve challenging materials problems and accelerate the development of new processes and products. As the only supplier that provides a full range of high performance XPS, AES, and SIMS instruments, PHI is in a unique position to provide complete surface analysis solutions to potential clients in a broad range of high technology fields including: nanotechnology, microelectronics, photovoltaics, storage media, catalysis, bio-materials, pharmaceuticals, and basic materials such as metals, polymers, composites, and coatings.

Our products are designed to provide high performance and reliability to meet our commitment to total customer satisfaction. Our skilled scientific staff, applications specialists, and global customer service organization provide an uncommonly high level of customer support.

To learn more about our products or how they can be used to meet your analytical needs, please visit our website or contact us directly.

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