

PHI VersaProbe

Product Description



Overview

The *VersaProbe* is the third generation multi-technique XPS instrument based on PHI's highly successful and patented scanning XPS microprobe technology. The *VersaProbe* provides: high performance large-area spectroscopy, x-ray beam induced secondary electron imaging for rapid and confident location of small sample features, unique micro-area spectroscopy performance, chemical state XPS imaging, high performance sputter depth profiling, automated angle dependent depth profiling, turnkey insulator analysis, and an instrument platform that accommodates alternative x-ray sources, ion guns, electron guns, and sample treatment chambers.

The *VersaProbe*'s unique x-ray source can produce x-ray beams from less than 10 μm to 300 μm in diameter. The focused x-ray beam is used to define the dimensions of points, lines, and areas for analysis. This unique approach directs all x-rays to the desired analysis area which maximizes sensitivity and minimizes the potential for x-ray induced sample damage.

Since the x-ray source is used to define the analysis area, the input lens for the *VersaProbe*'s energy analyzer does not need area definition apertures and is designed with one objective, maximum sensitivity. The *VersaProbe*'s electrostatic input lens overcomes the limitations of an electromagnetic input lens and provides high sensitivity whether a sample is thin or thick, polymer or steel.

A floating column sputter ion gun generates ion beams with energies from 5 eV to 5 keV. Whether you are studying thin film structures with thicknesses of microns or nanometers the *VersaProbe*'s ion gun provides the capability required to effectively and efficiently perform the experiment.

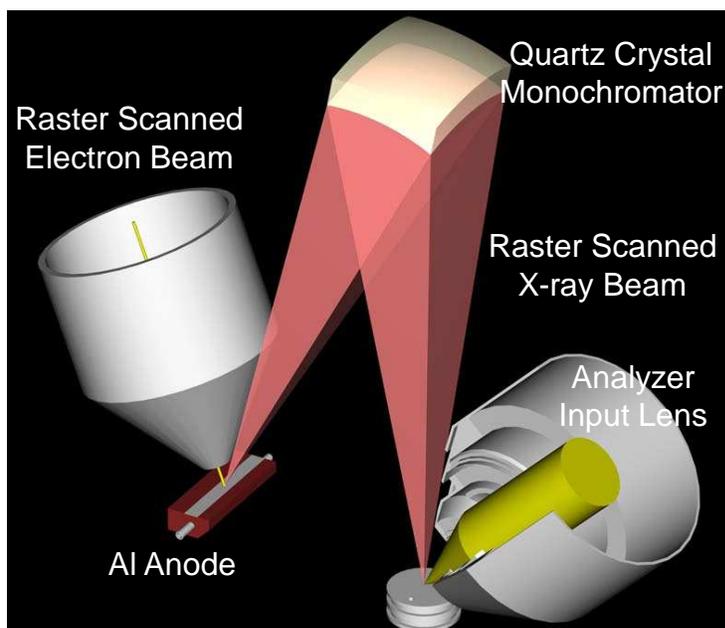
PHI's patented dual beam charge neutralization method eliminates sample-to-sample tuning and the need to mask insulating samples. This turnkey charge neutralization method coupled with an automated sample stage provides the ability to automatically analyze multiple insulating samples with no operator intervention.

SmartSoft-XPS, the new instrument control software for the *VersaProbe*, provides an easy-to-use task oriented user interface. Every aspect of the instrument is under software control and a queue function facilitates automated analysis of multiple samples. The instrument is internet ready and can be operated remotely.

PHI *MultiPak* provides a complete array of basic and advanced data processing tools for data interpretation and report generation.

Patented Monochromatic Scanning X-ray Source

The *VersaProbe* is driven by a unique x-ray source that provides a focused monochromatic x-ray beam that can be scanned upon the sample surface. The x-ray source utilizes a focused electron beam that can be electronically raster scanned upon an Al anode for x-ray generation and an ellipsoidally shaped quartz crystal monochromator that refocuses the x-ray beam onto the sample surface. Therefore, when the electron beam is scanned on the anode surface the refocused x-ray beam is scanned on the sample surface as shown below.



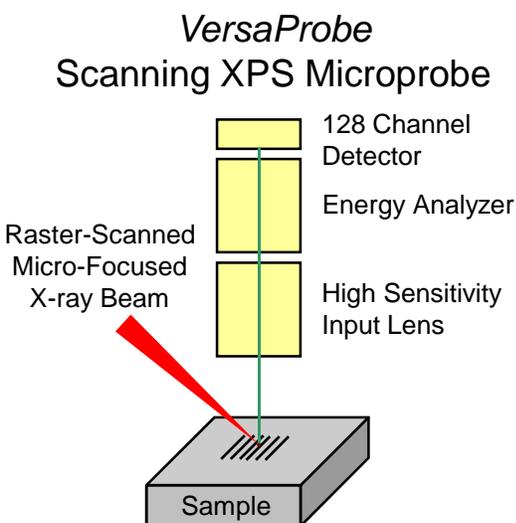
- * US Patent 5,315,113
- * US Patent 5,444,242
- * JP Patent P3752252
- * JP Patent P3754696
- * EP Patent 0590308B1
- * EP Patent 1170778A3
- * EP Patent 1220280A3

The diameter of the x-ray beam is user selectable from less than 10 μm to 300 μm in diameter. The focused x-ray beam can be used to define single or multiple analysis points, areas, lines, and maps. This unique x-ray source directs all the x-rays to the selected analysis area, which maximizes sensitivity and minimizes the potential for x-ray beam damage.

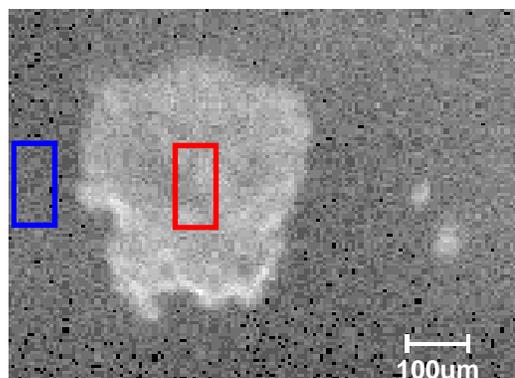
This unique x-ray source also provides a high performance large area analysis capability. Operating in a mode analogous to a rotating anode, a 100 W - 100 μm diameter x-ray beam is scanned 1.4 mm in the non-dispersive direction of the x-ray monochromator at high speed, providing a rectangular analysis area with both high sensitivity and high energy resolution.

Unique Scanning X-ray Imaging (SXI™)

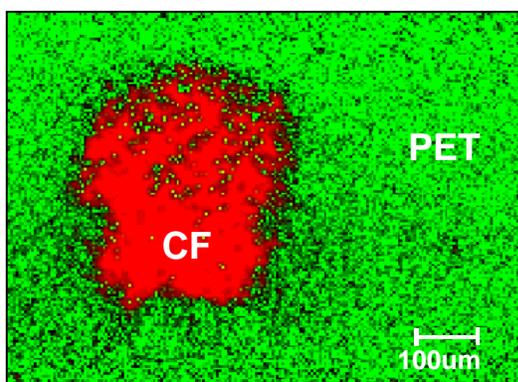
The *VersaProbe* provides x-ray excited secondary electron imaging of the sample surface in a manor analogous to how an SEM generates a secondary electron image. This unique feature utilizes the scanned x-ray beam to generate secondary electrons that are collected by the *VersaProbe*'s energy analyzer to provide images that contain topographical or surface chemical contrast information in a few seconds. The use of the same hardware for secondary electron imaging and XPS measurements ensures that spectroscopic information is coming from areas selected on secondary electron images. This unique capability facilitates the rapid and confident location of small sample features for analysis.



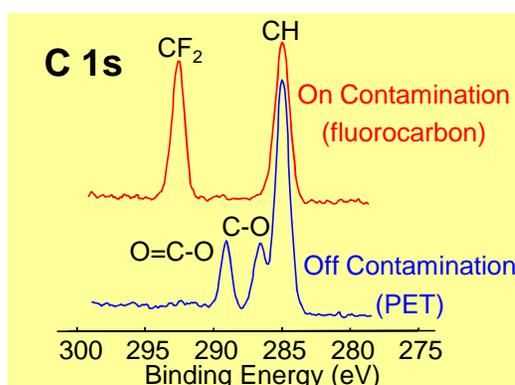
Secondary Electron Imaging of Contamination on a Polymer Film Not Visible with an Optical Microscope



C 1s Chemical State Maps



Micro-Area Spectroscopy



Uncompromised X-ray Photoelectron Spectroscopy

The *VersaProbe*'s spectrometer and unique x-ray source provide a full-featured XPS analysis capability including: large area spectroscopy, micro area spectroscopy, sputter depth profiling, mapping, line scans, and angle dependent depth profiling. This patented XPS microprobe instrument platform provides the same ultimate spatial resolution for spectroscopy and imaging. Detailed spectroscopy, depth profiling, imaging, and angle dependent measurements are available at all x-ray spot sizes with the analysis areas defined as points, rastered areas or multi-points. The versatile and high sensitivity spectrometer consists of an electrostatic input lens, a 180° spherical capacitor energy analyzer (SCA), and a multi channel detector (MCD). The spectrometer energy resolution can be user selectable based on the software selection of pass energy values from 6.5 eV to 280 eV

The input lens uses electrostatic lens elements that maintain high sensitivity on thin or thick samples, polymers and metals. Because the *VersaProbe* uses its x-ray beam to define the dimensions of the analysis area, the use of apertures in the input lens to define the analysis area is not required. This aperture-free lens design provides significantly higher sensitivity than aperture based input lenses.

The multi channel detector provides high dynamic range and further enhances spectrometer sensitivity. The MCD can be operated in both the scanned and unscanned (snapshot) detection modes. The scanned mode is the standard spectroscopy mode. In the scanned mode each data point is measured by each detector channel. This eliminates any detector signature and allows user selectable data point density. The unscanned mode is used for maps and lines scans and provides up to a 128 channel spectrum at each pixel that can be used to provide quantitative and chemical state information. Depth profiles can be obtained using either detection mode. The snapshot mode reduces data collection time and provides spectra with up to 128 data channels. The scanned mode allows the user to independently define the energy range, pass energy, and the number of data points (up to 4000 data points) for each spectral region.

Patented Charge Neutralization Capability

The *VersaProbe* is equipped with PHI's patented* dual beam charge neutralization system that utilizes both a cold cathode electron flood source (~1 eV) and a very low energy ion source (≤ 10 eV) to provide turnkey charge neutralization of all sample types. This unique capability eliminates sample to sample tuning of the neutralizer apparatus, eliminates the need for masking insulating samples, and makes it possible to automatically analyze multiple insulating samples with no operator intervention.

* JP Patent P3616714, US Patent 5,990,476 , EP Patent 0848247B1

High Performance, Sputter Depth Profiling

Features of the *VersaProbe* that contribute to its powerful sputter depth profiling capability include: the focused x-ray source, multi channel MCD, dual beam charge neutralization, *Compucentric Zalar Rotation*[™], and a floating column monatomic argon ion gun. For routine thin film analysis applications the ion gun can be operated between 1 and 5 kV with high etch rates. For ultra thin films the ion guns floating column can be used to generate a high current low energy ion beam (200 – 500 V). Low energy ion beams minimize sample damage and enhance interface definition. The ion gun is also equipped with a neutral filter to further enhance interface definition and minimize the sputtering of adjacent areas. The ion gun is completely software controlled and the use of software settings to define operating conditions improves day-to-day repeatability of etch rates.

High Performance Angle Dependent Analysis (ADXPS)

A dedicated sample holder is provided to facilitate automatic angle dependent XPS profiling with an angular range of 0° to 90° (photoelectron take-off angle). The *SmartSoft-XPS* instrument control software, provides eucentric tilt compensation to ensure the same location is analyzed at each angle. Two analyzer angular acceptance modes are available: $\pm 20^\circ$ and $\pm 5^\circ$. The $\pm 5^\circ$ mode utilizes a mechanical aperture. PHI *MultiPak* contains spectral manipulation tools for chemical state analysis including curve-fitting and linear least squares fitting of ADXPS data files. *MultiPak* also contains an ultra thin film analysis tool to provide a stratification model of the measured thin film structure.

Sample Handling

The *VersaProbe*'s motorized five axis sample stage accepts 25 mm and 60 mm diameter sample platens that are provided with the instrument. 60 mm samples up to 8 mm thick and smaller samples up to 13 mm thick can be mounted for analysis.

The vacuum processing required to introduce a sample platen is under software control. Sample platens are transferred from the introduction chamber to the test chamber using a magnetically coupled transfer rod.

In the central region of a sample platen, *Compucentric Zalar Rotation* can be used to designate a specific location as the center of rotation, and to improve layer (interface) definition by minimizing sputtering artifacts associated with sputtering at a fixed angle. A dedicated sample holder is provided to facilitate automatic angle dependent XPS profiling with an angular range of 0° to 90°. *SmartSoft-XPS*, the instrument control software, provides eucentric tilt compensation to ensure the same location is analyzed at each angle.

Automation

The automated analysis of multiple areas or samples is facilitated by several key features of the *VersaProbe*. The sample stage is completely software controlled with the ability to define and store multiple analysis positions anywhere on the sample platen for automated multi-point analysis. PHI's patented dual beam charge neutralization makes it possible to move from sample to sample with no neutralizer tuning, even if the samples have a different composition or shape. A robust Auto-Z capability makes it possible to reliably and automatically find the correct sample Z height for each sample in an analysis queue. Instrument settings for hardware control and analysis setup make it possible to program multiple measurements and to repeat a specific measurement in the future.

UHV Test Chamber

The *VersaProbe*'s test chamber provides a true Ultra-High Vacuum (UHV) environment to prevent vacuum related contamination of the surface being measured. A 480 l/s differential ion pump and a 1,000 l/s titanium sublimation pump are used to maintain a UHV environment in the test chamber. The sample introduction chamber, differential ion gun pumping, and test chamber roughing are accomplished using a 67 l/s turbomolecular pump.

User Interface and Data Station

The user interface for the *VersaProbe* is provided by two software packages that reside on a Hewlett-Packard® personal computer that uses an Intel Pentium® processor and a Windows® system. *SmartSoft-XPS*, the instrument control software, provides a task oriented user interface and software control of all instrument functions. Data reduction is accomplished via a seamless interface to *MultiPak*, PHI's advanced data manipulation software. The Windows operating system and an integrated LAN port provide the tools required to connect the *VersaProbe* to a local computer network.

The *VersaProbe* is internet ready and can be operated remotely using a number of off the shelf software products. At PHI we typically use VNC software for remote viewing and operation of our instruments.

VersaProbe Optional Accessories

Optional 20 kV Ar₂₅₀₀⁺ Gas Cluster Ion Gun

The optional Ar gas cluster ion gun provides sputter depth profiling for a wide range of polymer and organic thin films. This unique ion gun also provides the ability to remove organic surface contaminants from inorganic and organic materials. The high pressure and high purity Ar gas flow is introduced into the ion gun and a giant Ar cluster is formed by rapid adiabatic expansion and injected into an electron impact ionizer. The Ar gas cluster ion beam (GCIB) is accelerated through the extraction lens which focuses the beam into a Wien filter where smaller clusters and mono-atomic Ar are removed. The energy of the Ar cluster ion can be adjusted from 2.5 kV to 20 kV. An isolation valve is integrated into the ion optics to allow source maintenance without breaking vacuum in the analytical chamber. The ion gun column has a 4 degree bend to eliminate neutral particles from the ion beam and to preserve sample chemistry, enhance depth resolution, and minimize sputtering of adjacent areas. The dedicated differential pumping system that is configured with turbo pumps, mechanical oil rotary pumps, and a water chiller.

The optional electron gun for AES cannot be installed with this option. When this option is selected it is required that the main chamber ion pumps be replaced with a turbo molecular pump.

Optional C₆₀ Sputter Ion Guns

The optional 10 keV or the optional 20 keV C₆₀ sputter ion gun can be mounted on the test chamber to provide surface cleaning capabilities for removing contamination from polymer samples. This unique feature also allows sputter depth profiling of many polymer thin films with minimal chemical damage. C₆₀ powder is evaporated and injected into an electron impact ionizer. The C₆₀ ion beam is accelerated through an extraction lens which focuses the beam at a Wien filter aperture for mass separation. An isolation valve is included to allow source maintenance without breaking vacuum in the analytical chamber. The ion gun column has a 1 degree bend at the blanking plate for eliminating neutral particles to preserve sample chemistry, enhance depth resolution, and minimize sputtering of adjacent areas.

Optional Ultraviolet (UV) Photon Source

The optional UV source provides low energy photons for valence band and Fermi edge measurements. The following gasses can be used to generate single and doubly ionized UV photon sources: He, Ne, Ar, Kr, and Xe. A dedicated differential pumping station is provided to reduce the volume of source gas admitted into the test chamber. A software selectable "UPS" mode is available to operate the spectrometer in a high precision mode that provides data step sizes as small as 0.005 eV.

Optional Dual Anode X-ray Source

The optional PHI Model 04-548 dual anode x-ray source provides alternative photon sources that can be used to excite higher energy photoelectron peaks or Auger electron peaks that are not accessible with Al K_{α} x-rays. The most commonly used dual anode combinations are Mg/Al and Mg/Zr.

The power supply for the dual anode x-ray source provides software control of anode selection and x-ray power. The high voltage can be varied from 4 to 15 keV. 15 keV is recommended for optimum performance. The maximum power is 400 W for a single anode or 600 W if operating both anodes simultaneously. A recirculating heat exchanger water cools the dual x-ray anode and x-ray source housing and is shared with the scanning x-ray source. Sensors are included to provide safety interlocks for coolant flow rate, vacuum, and high voltage.

Optional Hot/Cold Sample Stage

This option replaces the ambient temperature stage and the sample introduction fork. This option allows the central area of the sample holder to be temperature controlled on the sample manipulator with a nominal temperature range of -140° C to $+600^{\circ}$ C. A heating only sample holder is also available with a temperature range of RT to 800° C. All 5 axes moments are maintained including Zalar Rotation and sample rotation which is accomplished with $\pm 180^{\circ}$ stage motion.

Optional Vacuum Transfer Vessel

The optional vacuum transfer vessel accepts standard PHI 25 mm diameter sample platens and can be used to provide inert gas transfer from a glove box environment or vacuum transfer from another surface analysis instrument or sample treatment apparatus. A flange is provided on the transfer vessel to allow vacuum pumping of the vessel or to admit an inert gas.

Optional Electron Gun for AES

The 10 kV Auger option with a LaB_6 emitter provides the functions of secondary electron imaging, Auger Electron Spectroscopy from 50 eV to 2200 eV, Auger mapping, Auger line scans and Auger depth profiling. The minimum diameter of the electron beam will be less than 100 nm for a stand-alone system. The sensitivity for Cu LMM at 0.1% resolution is > 1.6 Mcps with a 10 kV -10 nA electron beam. Installation of a mu-metal chamber is required for this option.

Optional Optical Camera Above Introduction Chamber for Sample Navigation

In addition to the standard secondary electron imaging (SEI) produced by the scanning x-ray source and the optical image produced by the *in situ* optical camera, an optional optical camera above the introduction chamber can be selected for a third form of sample navigation. The SEI image has an ultimate spatial resolution of 10 microns, a field of view of 1.4 mm by 1.4 mm, and a depth resolution of about 10 nanometers, and is sensitive to differences in elemental composition. The optical image acquired by the optical camera above the introduction chamber has an ultimate spatial resolution better than 30 microns, a field of view larger than 60 mm in diameter, and a depth resolution of a few hundred nanometers. All three forms of imaging can be used for sample navigation and for the selection of multiple points for unattended, multiple area sample analysis.



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