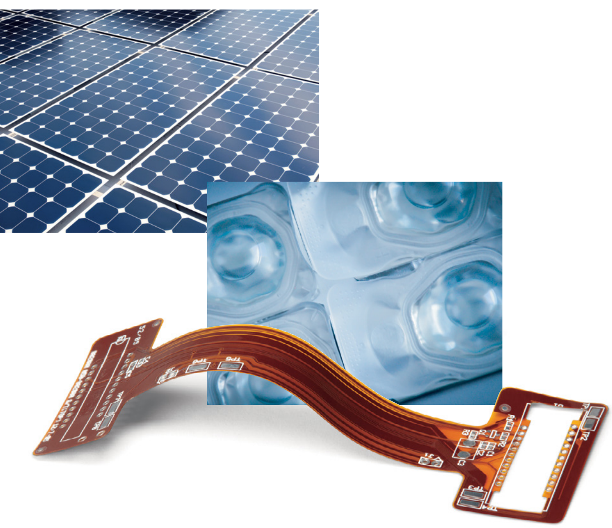
Thermo Scientific MAGCIS Dual Mode Ion Source

Next generation ion source for X-ray photoelectron spectroscopy

The Thermo Scientific™ MAGCIS™ dual mode ion source operates as both a monatomic ion source and gas cluster ion source, enabling depth profiling analysis and surface cleaning of both soft and hard materials on the same XPS instrument.

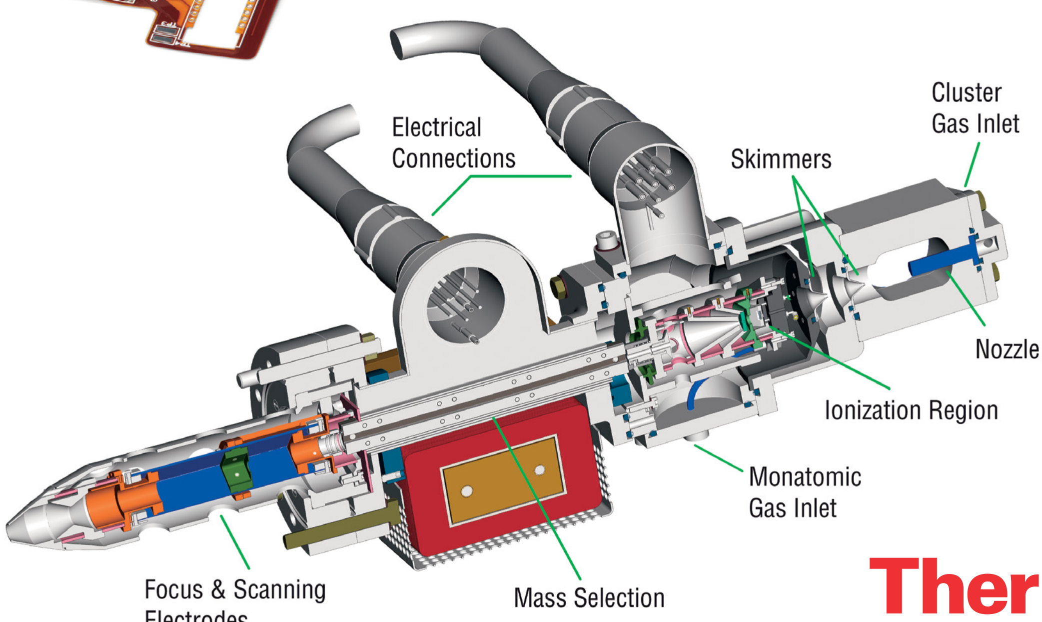


Depth profiling is important to many X-ray Photoelectron Spectroscopy (XPS) applications, such as investigating the oil-resistant coatings on touch screens, measuring plasma deposited coatings for bio-medical devices or understanding OLEDs and solar cells. Monatomic ion sources, typically using Ar^{+} as a projectile, have been used for decades to investigate changes in chemistry across the depth of a layered material or to clean inorganic surfaces.

A monatomic ion source, however, has limitations when used on softer materials, where ions will induce damage in the surface, changing the chemistry of the analyte. New gas cluster ion sources overcome these limitations, enabling the analysis of several classes of materials previously inaccessible to XPS depth profiling. The Thermo Scientific MAGCIS ion source operates in both monatomic and gas cluster modes, allowing depth profile analysis of the wide range of sample types.

Applications

- Depth profiles of polymer multi-layers
- Surface cleaning of oxides and glasses
- Depth profiles of mixed materials (polymer/inorganic)
- Depth profiles of metals and oxides
- Understanding polymer electronics
- Analysis of graphene-based devices
- Conformity of bio-medical coatings
- Comparing fabric treatments
- Organic and inorganic solar cells
- Preparing high-k materials for angle-resolved XPS



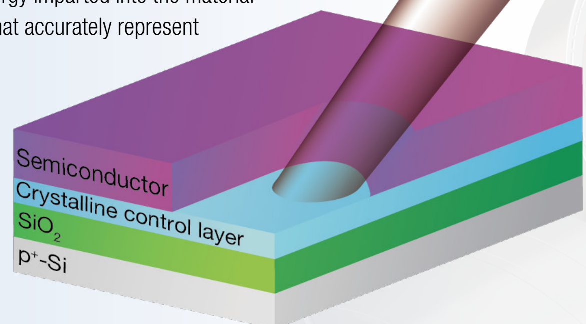
Thermo SCIENTIFIC

Gas Cluster Ion Beams

Devices composed of both organic and inorganic layers are finding increasing use in materials engineering. For XPS analysis this requires a dual mode ion source that can remove both classes of materials without altering the chemistry of the remaining surface. XPS systems fitted with a source producing monatomic argon ions work particularly well for inorganic materials, although they can induce reduction in some oxides. Using a monatomic ion beam on polymers almost always results in damage to the remaining surface, making accurate analysis of the structure impossible.

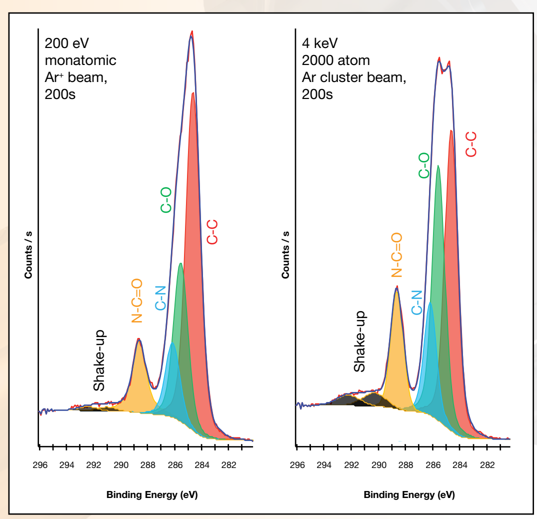
Gas cluster ion sources allow depth profiling of the increasing number of polymer-based systems. The key to minimizing the damage is to reduce the energy going into the surface, while still having enough to remove material. By making our projectile much heavier, using a weakly bound cluster of gas atoms, we can still remove material but we can spread the energy and single charge across the whole cluster. This vastly decreases the “damage zone” in the remaining surface, as there is significantly less energy imparted into the material by the cluster impact, and results in XPS spectra that accurately represent the real surface chemistry.

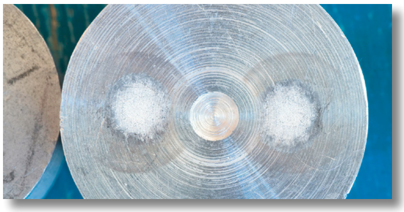
Gas cluster profile through an organic semiconductor layer. Once this layer is etched, the MAGCIS source is switched to monatomic mode to etch the crystalline OTS layer and SiO_2 layer.



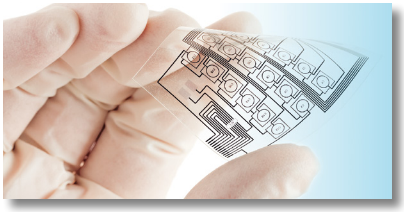
Minimizing Sample Damage

- Many polymers cannot be sputtered with monatomic argon.
- Chemical information is destroyed and composition is modified.
- Polyimide is a polymer that is especially sensitive to ion beam damage. The results of exposure of a sheet of Kapton® to monatomic and cluster ion beams are shown here.
- The C1s spectra clearly show that the chemistry is retained after cluster sputtering, but damaged after sputtering with a monatomic beam.





Metals and Oxides

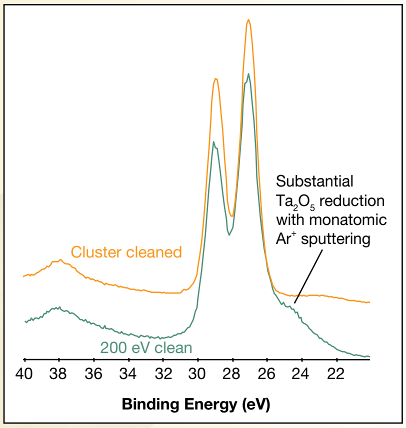


Organic Electronics

Food Packaging

Cleaning Inorganic Samples

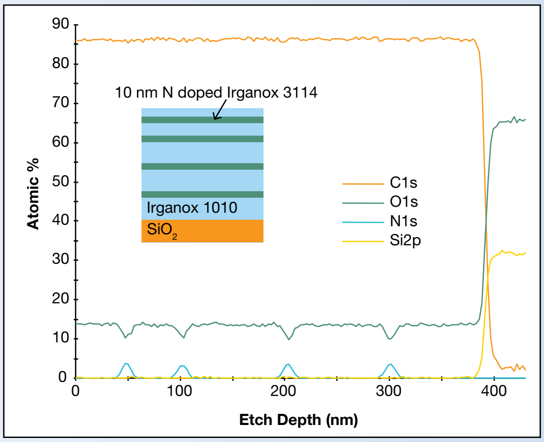
- Inorganic materials can be modified by monatomic sputtering.
- Although cluster ion beams are not typically used for profiling inorganic materials such as oxides, they can be very useful for removing surface contamination without the risk of modifying the chemistry.
- The example on this page shows the result of cleaning away surface carbon from a Ta_2O_5 sample using monatomic and cluster ion beams. Even at low energies, the monatomic beam reduces around 25% of the surface oxide, whereas no reduction is seen following cluster cleaning.
- This is useful for many classes of materials, such as glasses, ceramics and superconducting mixed oxides.



Comparison of Ta 4f spectra for monatomic Ar^+ and argon cluster ion sputter-cleaning of Ta_2O_5

Polymer Depth Profiles

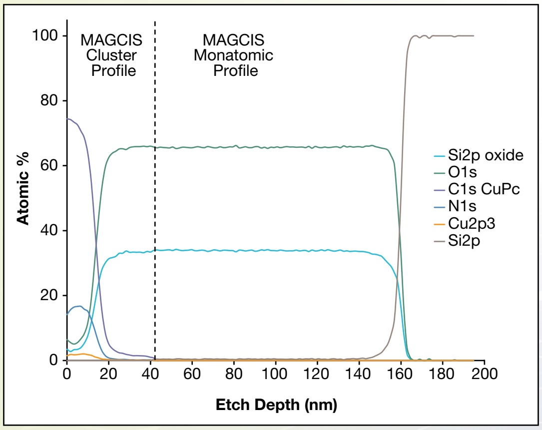
- The MAGCIS dual mode ion source allows users to investigate samples that have been impossible to analyze before.
- The range of beam energies and cluster sizes means that samples with very thick or very thin layers can easily and quickly be depth profiled.
- Excellent depth resolution can be maintained, as seen with a profile through 10 nm nitrogen-doped Irganox® delta layers in an Irganox 1010 matrix. (Reference standard kindly supplied by the National Physical Laboratory, UK.)
- Other application areas include developing amino acid layers for bio-sensors, understanding graphene-based devices, and novel display technologies based around polymer electronics.



MAGCIS cluster profile of Irganox [deltaΔ]-layers] in NPL reference standard

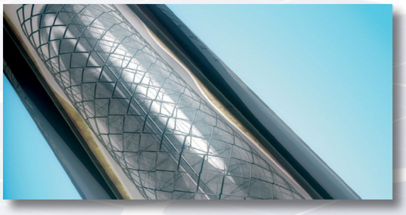
Multi-mode Depth Profiles

- Devices are not usually based around one type of material, but may be a mixture of organic and inorganic compounds.
- The twin operating modes of the MAGCIS source facilitate depth profiles of both organic and inorganic materials. The Thermo Scientific™ Avantage™ XPS data system controls simple mode switching during the experiment.
- The example analysis of an organic FET device, shown here, is a good example of multi-mode depth profile.
- The MAGCIS source performs the first part of the profile in cluster mode to preserve the sensitive organo-metallic chemistry, before changing to monatomic mode for the inorganic layer, creating a full profile of the entire device.

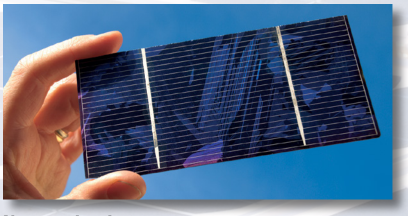


Depth profile of an organic FET showing both monatomic and gas cluster ion etching

Biomaterials



Medical Devices



Nanotechnology

System Integration

- The MAGCIS dual mode ion source is available on Thermo Scientific Surface Analysis Instruments:
  - *– Thermo Scientific™ K-Alpha+™ X-ray photoelectron spectrometer*
  - *– Thermo Scientific™ ESCALAB™ Xi+ XPS microprobe*
  - *– Thermo Scientific™ Theta Probe angle-resolved XPS system*
- The ion source is fully controlled by the Avantage XPS data system.
- All gas handling and pumping requirements are computer-controlled and completely transparent to the user, allowing fast switching between cluster and monatomic ion modes.
- The Avantage XPS data system is a full suite of data processing tools to help analysts interpret their results.

Specifications

- Patented* dual mode design
- Variable cluster size (up to 2000 atoms)
- Cluster energy/atom from 1 eV upwards
- Monatomic Ar^+ mode (0.5–4 keV)
- Fast, automated mode switching
- Full control through Avantage data system
- Automated set-up and alignment
- Available on all Thermo Scientific XPS instruments

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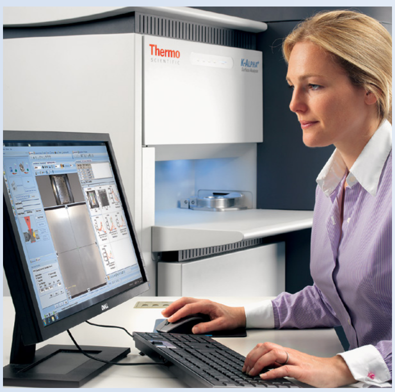

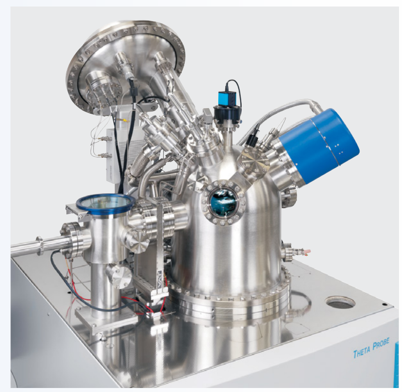

K-Alpha+ XPS System

High Performance X-ray Photoelectron Spectroscopy

- Rapid, intuitive workflow
- Interactive and fully automated operation
- Remote operation via internet
- Self-calibration via internal standards
- MAGCIS dual mode ion source

ESCALAB Xi+ XPS Microprobe

Ultimate Performance and Versatility

- Fast, quantitative parallel imaging
- Sub-5 µm retrospective spectroscopy
- Ultimate energy resolution
- REELS and ISS as standard
- Multi-technique options (AES, UPS)
- MAGCIS dual mode ion source

Theta Probe PARXPS System

Powerful Thin Film Analysis

- Parallel angle-resolved XPS
- Non-destructive depth analysis
- Complete ARXPS software toolset
- Micro-focused X-ray for small features
- Multi-technique and preparation options
- MAGCIS dual mode ion source

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