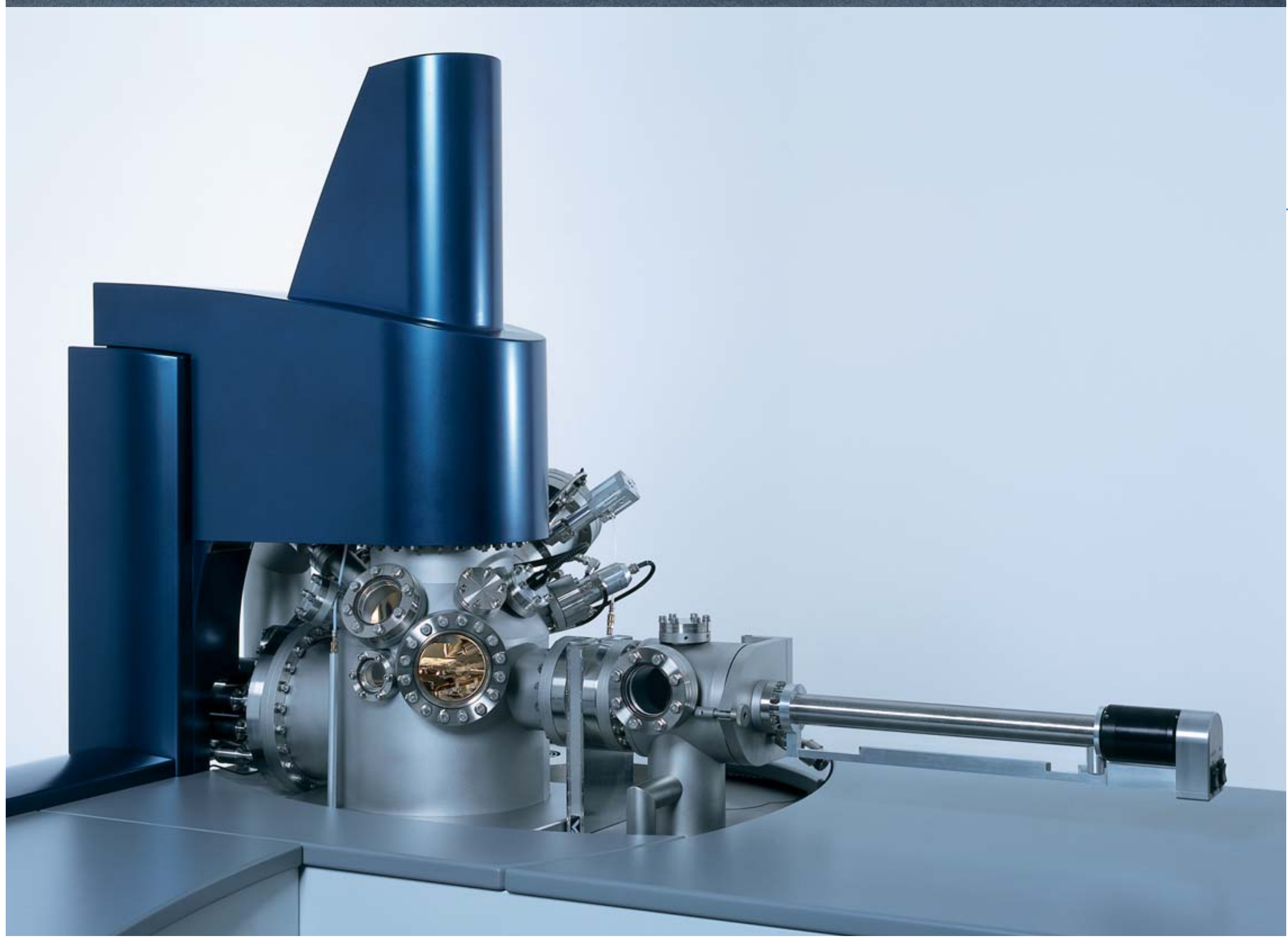
qtac[100]

QUANTITATIVE TOP ATOMIC LAYER CHARACTERISATION



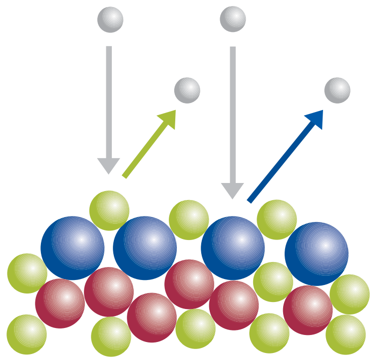
Quantitative elemental characterisation of the top atomic layer

The Qtac^{100} is a high sensitivity low energy ion scattering (LEIS) instrument. It is extremely surface sensitive, providing elemental and structural characterisation of the top atomic layer.
This new generation instrument has been developed to include small spot analysis, surface imaging, and both static and dynamic depth profiling. Its unique surface sensitivity makes the Qtac^{100} the perfect tool to study surface processes. The Qtac^{100} provides valuable information in many production and research areas on materials such as catalysts, semiconductors, metals, polymers, fuel cells, and biomaterials. Key features are:

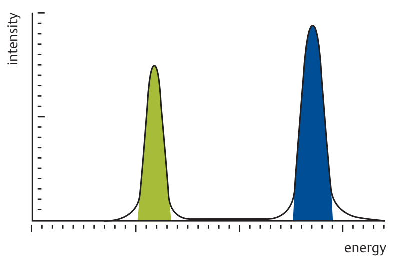
- **3000 times higher sensitivity than conventional LEIS instruments**
- **Quantitative, elemental characterisation of the top atomic layer**
- **Spectroscopy, imaging and depth profiling capabilities**
- **Time-of-flight mass filtering for improved sensitivity**
- **Analysis of rough and non-conductive materials**

3000 times higher sensitivity than conventional LEIS instruments

Principle of LEIS
In LEIS analysis the sample surface is bombarded with noble gas ions at an energy of a few keV. The ions are scattered by the atoms of the surface following the laws of the conservation of energy and momentum. By measuring the energy of the backscattered ions the masses of the scattering surface atoms are determined. With the advanced analyser design of the Qtac^{100} the measured intensity is directly proportional to the surface coverage of the corresponding element and is not influenced by the chemical environment. This allows matrix independent quantification.



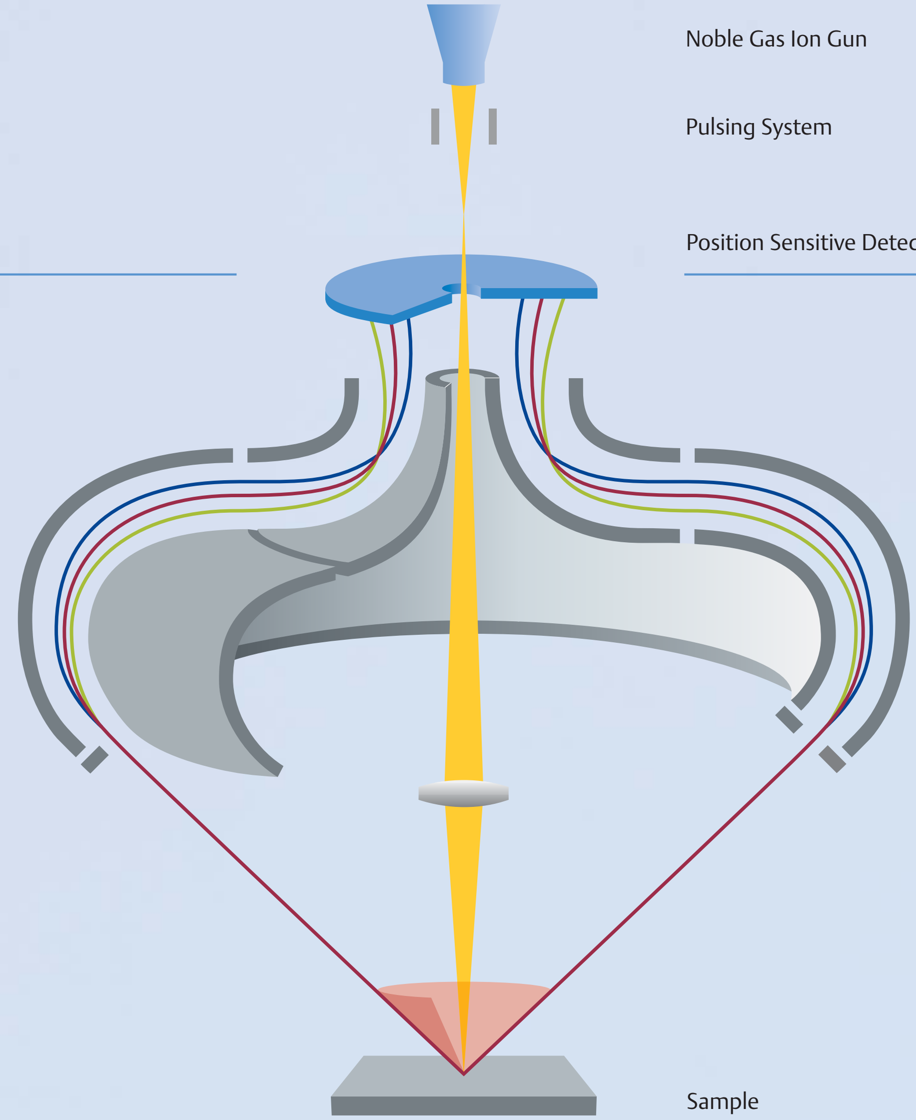
Scattering of noble gas ions by surface atoms



Energy spectrum of the scattered ions corresponding to the masses of the surface atoms

Qtac^{100} Energy Analyser
The unique Qtac^{100} energy analyser design is based on the advanced Calipso technology. At the optimum scattering angle, the analyser has an acceptance over the full azimuth. This, together with parallel energy detection, provides 3000 times higher sensitivity than conventional ion scattering spectrometers, thus enabling the non-destructive, reproducible and quantitative analysis of the top atomic layer. The high energy resolution of the Qtac^{100} allows the unambiguous identification of the analysed elements.

INSIDE THE Qtac^{100}



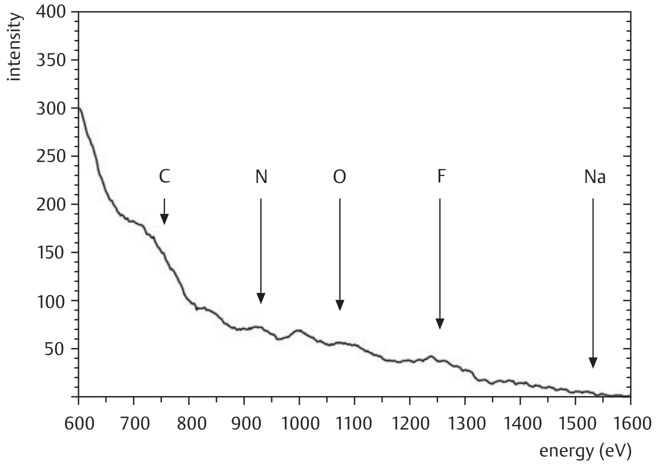
Static Depth Profiling

In LEIS the majority of the ions detected are scattered at the surface. Those scattered from atoms below the surface lose additional energy proportional to the depth at which the scattering occurred. By measuring this energy loss, the elemental composition of sub-surface layers is determined non-destructively. This static depth profiling provides information down to a depth of 10 nm.

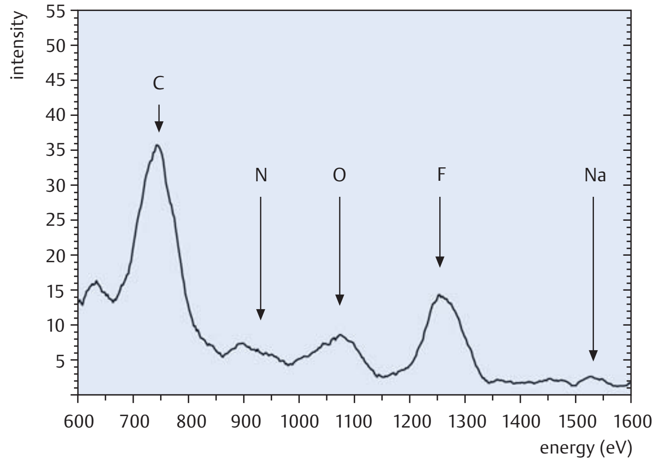
This mode also allows a quantitative measurement of the thickness of organic overlayers such as Langmuir-Blodgett films or self-assembled monolayers.

Time-of-Flight Mass Filter

In conventional LEIS, secondary ions, generated by the impact of the noble gas ions, lead to a high background for low scattering energies. This background reduces dynamic range and detection limits, in particular for light elements. The Qtac^{100} is equipped with a time-of-flight detection system, which separates the scattered noble gas ions from this background. This unique feature significantly improves the elemental detection limits and the dynamic range of the instrument.



LEIS spectrum of a technical polymer without time-of-flight mass filtering



LEIS spectrum of the same sample with time-of-flight mass filtering showing significantly improved detection limits

Key technology for a detailed understanding of surface processes

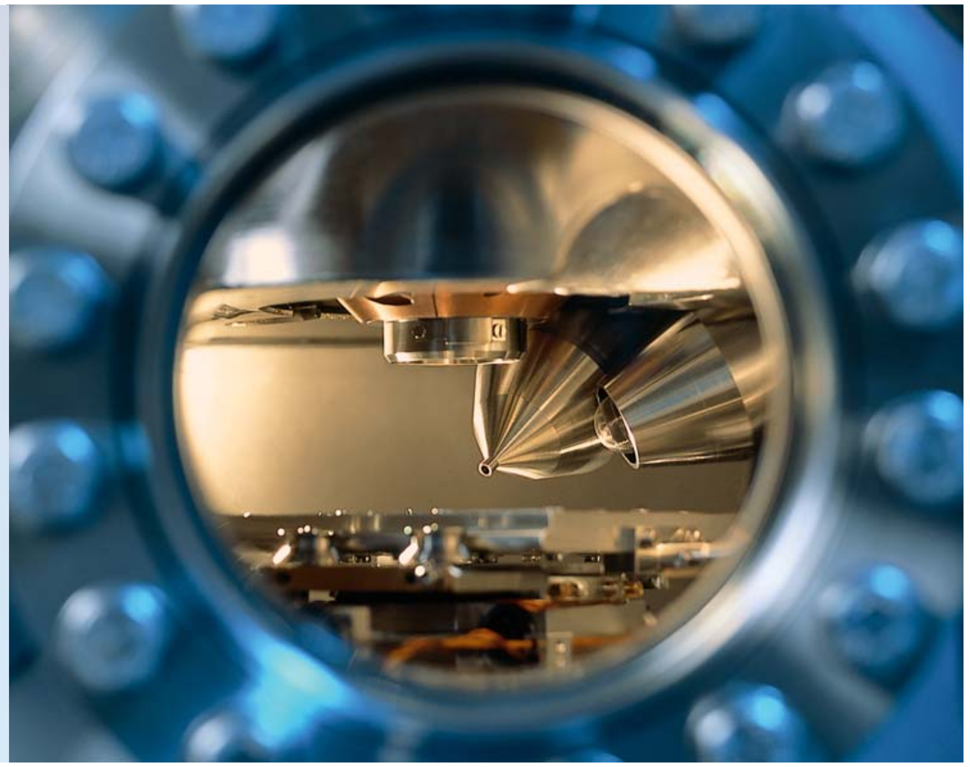
Take a Closer Look at the Surface

Many interactions of a solid surface with other solids, liquids or gases involve only the atoms in the first monolayer. To obtain a clear understanding of these processes the analysis of the first atomic layer is crucial.

The significant advantages of low energy ion scattering (LEIS) are extreme surface sensitivity and quantification. Contrary to many other established surface analysis techniques such as XPS or AES, which generally integrate over several atomic layers, LEIS characterises individual atomic layers. These features make the Qtac^{100} an extremely valuable instrument when information about the composition of the first atomic layer is required. Static depth profiling is used to analyse the sub-surface atomic layers and to determine layer thicknesses.

The Qtac^{100} extends the range of LEIS applications to surface imaging and dynamic sputter depth profiling.

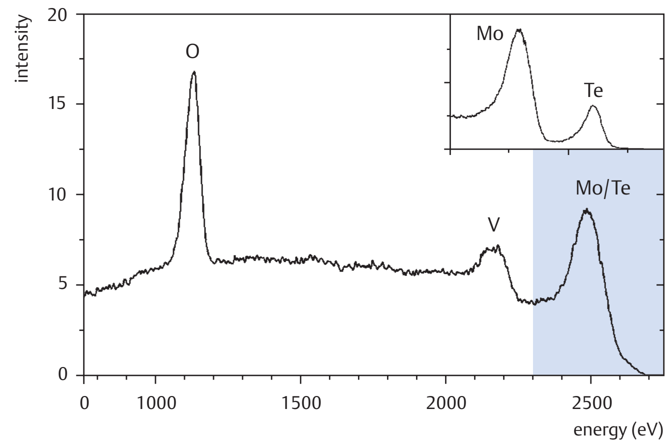
Materials	Tasks	Areas of Application
Catalysts	Research	Catalysis
Semiconductors	Development	Adhesion
Metals	Failure Analysis	Wettability
Polymers	Quality Control	Corrosion
Biomaterials	Process Control	Surface Homogeneity
etc.	High Throughput Screening	Biocompatibility
	etc.	etc.



Field of view: 2 x 2 mm^2
LEIS images of a metal structure showing the Ti and Cu distribution (top) and an overlay (bottom)

Catalysts

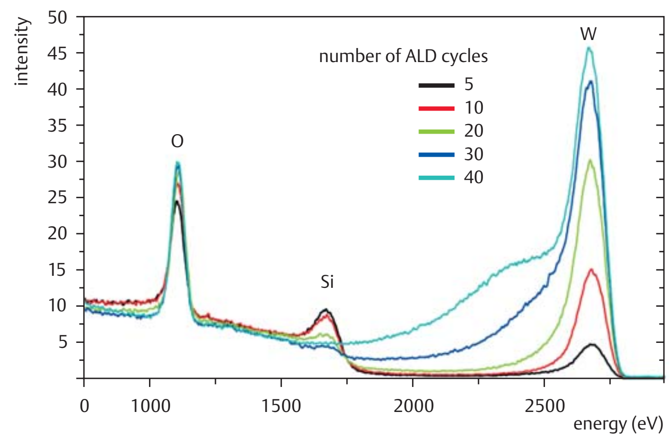
For catalysis the characterisation of the top surface layer of atoms is essential and the $Qtac^{100}$ is the perfect tool for this application. In this example it is used to study sub-monolayer coverages of Te, Nb and Sb oxides on Mo-V-O. This multi-component catalyst is used for the conversion of propane feedstock to acrylic acid and acrylonitrile, intermediary chemicals for the production of clothes, home furnishings, paints, adhesives etc.
The results show the surface composition of Mo-V-M-O (M=Te, Nb, Sb) catalysts. A study of different surface concentrations of Te, Nb and Sb reveals which combination gives the optimum selectivity and reaction rates.



Energy spectra showing the elements present in the top atomic layer of a Mo-V-Te-O catalyst
The inset shows a higher resolution spectrum acquired using neon instead of helium ion scattering

Ultra-thin Film Analysis

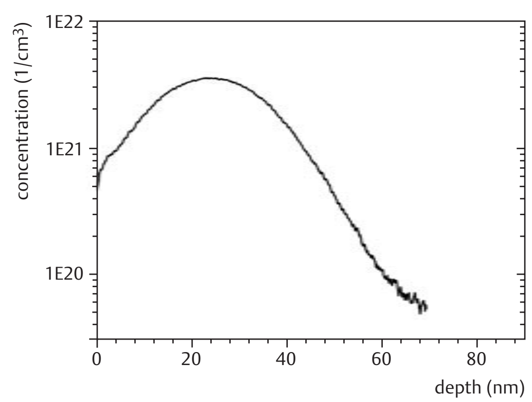
In the semiconductor industry ultra-thin films such as diffusion barriers and high-k materials are increasingly manufactured by atomic layer deposition (ALD). For process control the analysis of these films is essential. With the $Qtac^{100}$, detailed information about the layer composition, coverage and thickness is obtained.
The example on the right shows five different LEIS spectra taken after an increasing number of deposition cycles of WN_xC_y on silicon.
By monitoring the decreasing silicon and the increasing tungsten signal it can clearly be seen that 40 ALD deposition cycles are necessary for a closed layer of WN_xC_y. The peak shape on the left side of the tungsten surface peak also shows the growth of multiple layer islands before reaching full coverage.



LEIS spectra taken after an increasing number of ALD cycles of WN_xC_y on silicon

Ultra-shallow Implants

By using a low-energy sputter ion source, fitted to the $Qtac^{100}$, in a dual beam mode with LEIS analysis, high-resolution chemical depth profiles are obtained. In contrast to SIMS, there is no need to use reactive sputter species, which lead to changes in sputter rate and ionisation yield close to the surface. The $Qtac^{100}$ provides easy quantification even in the first few nanometres of the profile.



Sputter depth profile of a 30 keV arsenic implant into silicon, measured with LEIS analysis during 1 keV argon sputtering

One Technique, Three Solutions:

Qtac^{100}

The stand-alone version of the Qtac is based on a field-proven instrument platform. The modular design is ideal for customisation and the integration of a large variety of UHV preparation techniques. It is also possible to couple the Qtac^{100} to other floor standing instruments.

TOF.SIMS 5 with Qtac Extension

For many samples, including those with sensitive surfaces, the in-situ transfer between analytical techniques is very useful, avoiding contamination between analyses, and permitting direct comparison of results. The combination of the Qtac with the time-of-flight secondary ion mass spectrometer TOF.SIMS 5 makes a very effective tool for inorganic and organic surface analysis. The combination provides top atomic layer analysis, surface chemical mapping, static and dynamic depth profiling, 3D chemical imaging, layer thickness measurement, and quantification.

Adding the Qtac to Other Instrumentation

Many manufacturing, surface treatment, and thin layer deposition techniques benefit from on-line quality control. For coverage and layer thickness measurements, the Qtac makes an ideal addition. The Qtac is available as a bolt-on system, tailored to individual requirements, for laboratory instruments or industrial tools. ALD and MBE instrumentation are typical examples.

Qtac bolt-on module including energy analyser and noble gas ion source

Qtac bolt-on module attached to the preparation chamber of a TOF.SIMS 5

The Company

ION-TOF is the leading European manufacturer of TOF-SIMS instruments for surface analysis. Technical capability, performance, excellent after sales service, a deep understanding of the technique, the customer‘s needs, and the dedication to supply the best products have been the basis of ION-TOF‘s success. As a long-term technological leader in the field of TOF-SIMS instrumentation, ION-TOF is seen as a role model for the successful development of original university research into a professional business.

In 2007 ION-TOF expanded its product range to the complementary technique of high sensitivity low energy ion scattering (LEIS). Based on the pioneering research and instrument development carried out by Professor Brongersma and his group at the Eindhoven University of Technology, carried forward by Calipso BV, and their long term application experience, ION-TOF has developed the next generation of LEIS instruments.

The perfect instrument for composition analysis

ION-TOF GmbH
Heisenbergstraße 15
48149 Münster | Germany
Phone +49 (0)251 1622 100
Fax +49 (0)251 1622 199
sales@iontof.com
www.iontof.com