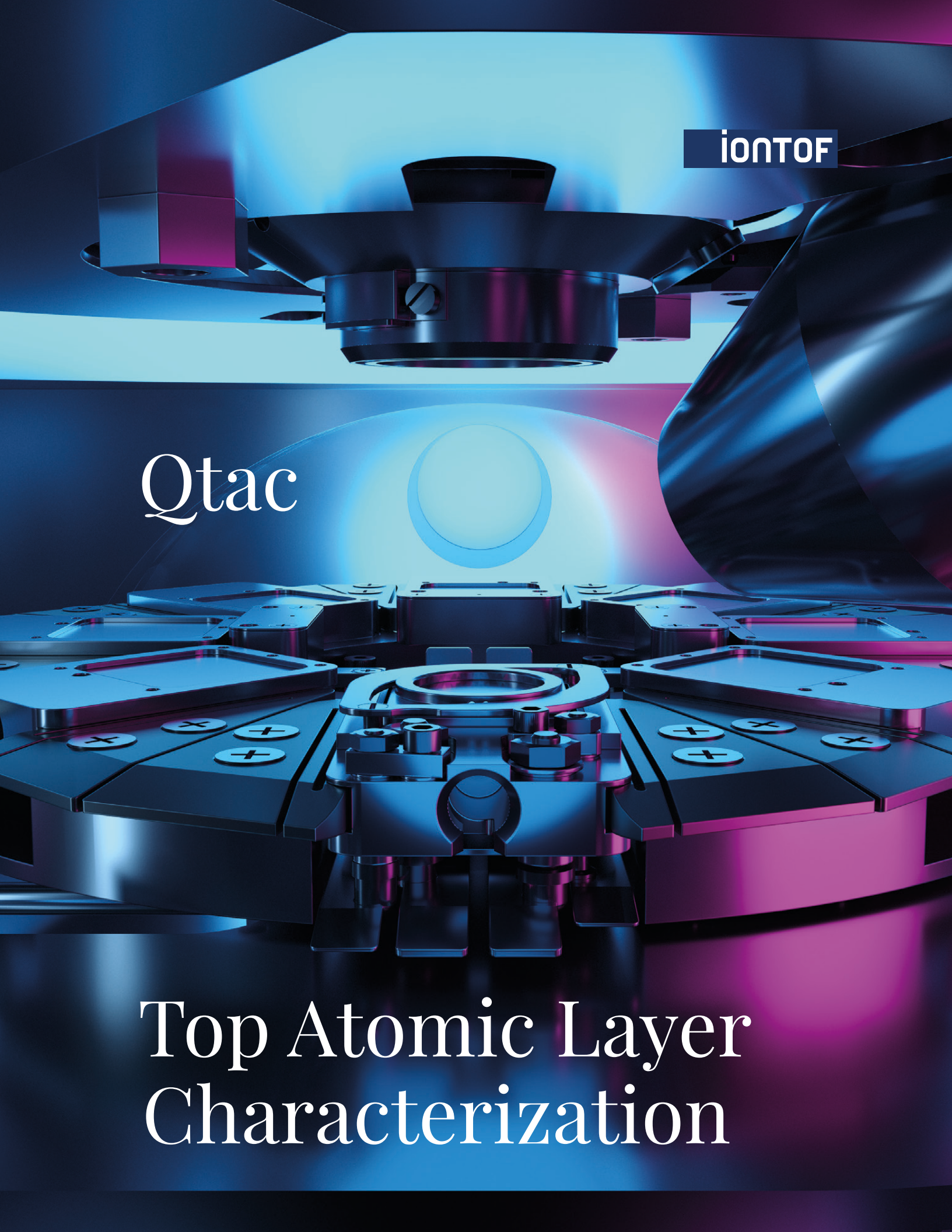


iONTOF

Qtac

Top Atomic Layer Characterization

Quantitative elemental

With the Qtac, IONTOF offers a high sensitivity and high-resolution Low Energy Ion Scattering (LEIS) platform. The instrument allows for small spot analysis, surface imaging, and both static and dynamic depth profiling. This provides quantitative elemental composition of the top atomic layer, as well as characterization of the first few nm of the sample.

The unique surface sensitivity of LEIS makes the Qtac the perfect tool to study surface processes in many production and research areas on materials such as catalysts, semiconductors, metals, ceramics, polymers and nanoparticles.

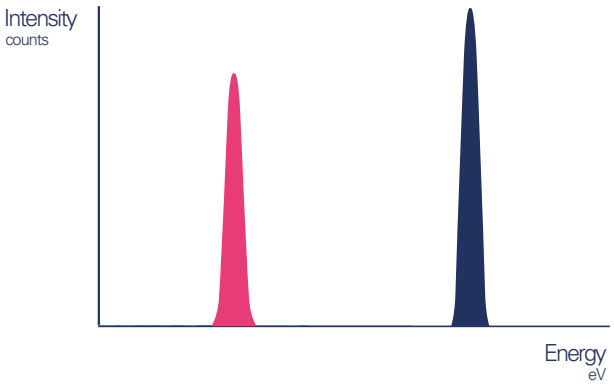
1. Quantitative elemental characterization of the top atomic layer
2. Non-destructive layer thickness measurement
3. Spectroscopy, imaging, and depth profiling capabilities
4. Time-of-flight mass filtering for improved sensitivity
5. Analysis of rough and non-conductive materials
6. Extensive in-situ sample heating and sample preparation options

characterization

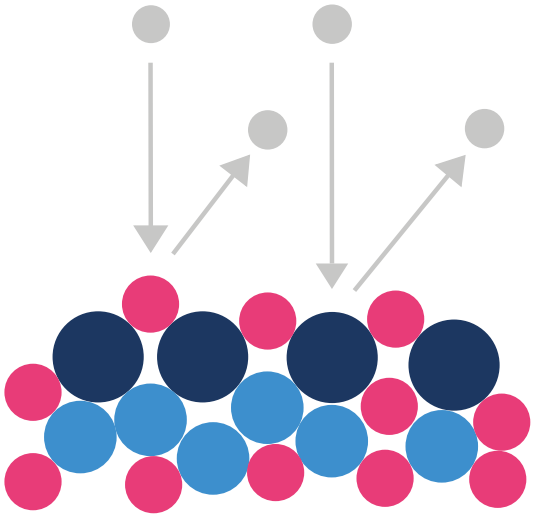
Low Energy Ion Scattering

Principle of LEIS

In LEIS analysis the sample surface is bombarded with noble gas ions of a few keV kinetic energy. The ions are scattered by the atoms of the surface and exhibit a mass dependent energy loss. By measuring the energy of the backscattered ions, the masses of the surface atoms are determined. The measured intensity is directly proportional to the surface coverage of the corresponding element and is generally not influenced by the chemical environment. This allows matrix independent quantification.



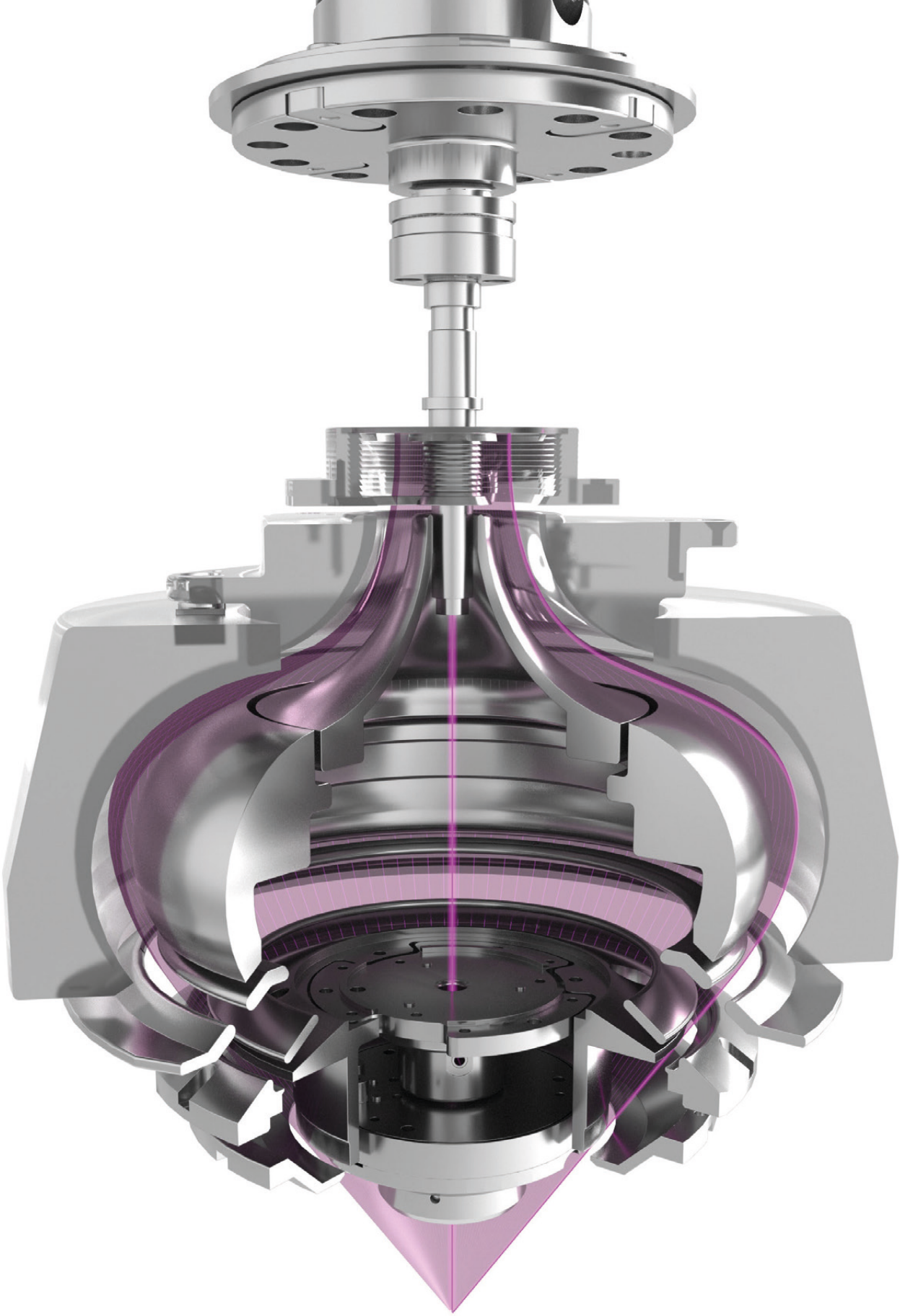
Energy spectrum of the scattered ions corresponding to the masses of the surface atoms



Scattering of noble gas ions by surface atoms

Unique Analyzer Technology

The unique Qtac energy analyzer is optimized for Low Energy Ion Scattering. While having a well-defined scattering angle for high mass resolution, the analyzer has an acceptance over the full azimuth for highest transmission. In combination with parallel energy detection, a sensitivity several orders of magnitude higher than conventional ion scattering spectrometers is achieved. This allows for non-destructive, reproducible, and quantitative analysis of real-world samples.



High sensitivity and high mass resolution simultaneously

Take a closer look at the surface

Investigating solid-surface interactions

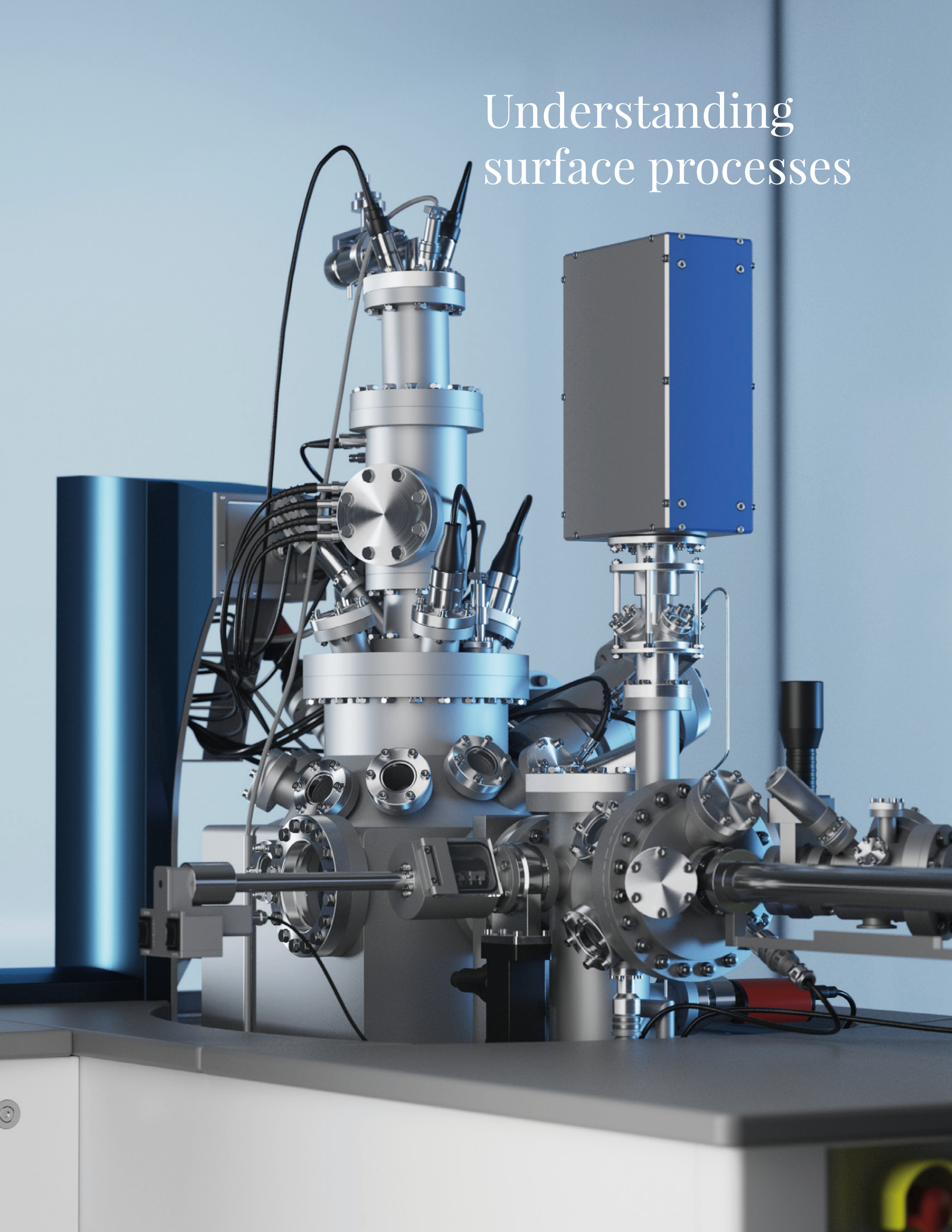
Many interactions of a solid surface with other solids, liquids, or gases involve only the atoms in the first monolayer. To obtain a clear understanding of these processes, the analysis of the first atomic layer is crucial.

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 or even many atomic layers, LEIS characterizes individual atomic layers. Additional information from static depth profiling is used to analyze the sub-surface layers and to determine layer thickness.

The Qtac extends the range of LEIS applications to surface imaging and dynamic sputter depth profiling. The main areas of application are thin films and catalysis, but the Qtac is also used in all areas where the outer surface determines the material properties.

1. Early stages of thin film growth, e.g. nucleation, growth mode, thickness, composition
2. Pinhole detection
3. Trace elements/contaminants in the outer atomic layer
4. Diffusion, e.g. metal into polymer or oxide
5. Segregation towards the surface
6. Catalysis
7. Fuel cell materials
8. Nanoparticles, e.g. diameter, core-shell structure, chemistry of surface
9. Development and control of cleaning procedures

Understanding surface processes



Analytical and instrumental features

Static Depth Profiling

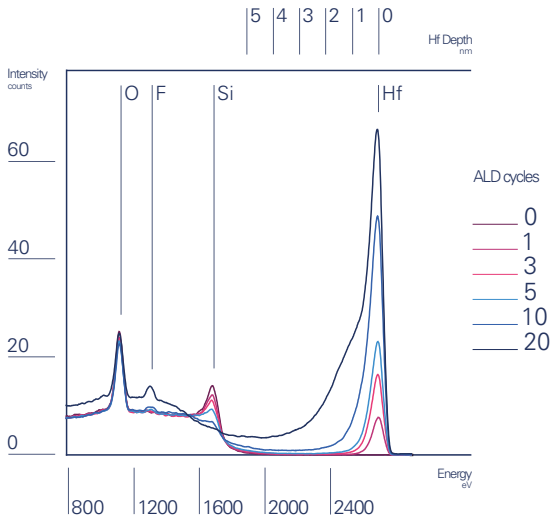
The peaks in the LEIS spectrum correspond to the ions scattered at the outer surface. Those ions scattered from atoms below the surface lose additional energy, proportional to the depth at which the scattering occurred. By measuring this energy loss, the elemental composition of sub-surface layers is determined non-destructively. This static depth profiling provides information down to a depth of 5 - 10 nm and provides information about film thickness and interface width.
Together with the composition of the outer atomic layer and therefore the surface coverage, the growth mode of a film can be determined at all stages of film formation.
In the example on the left, the surface composition including a fluorine contamination and the HfO_2 film thickness are analyzed during film growth on Si. The average film or island thickness during film growth on a Si substrate can be measured simultaneously with the surface coverage, which is essential for the evaluation of the process during the early stages of film growth.

Heavy Primary Ions

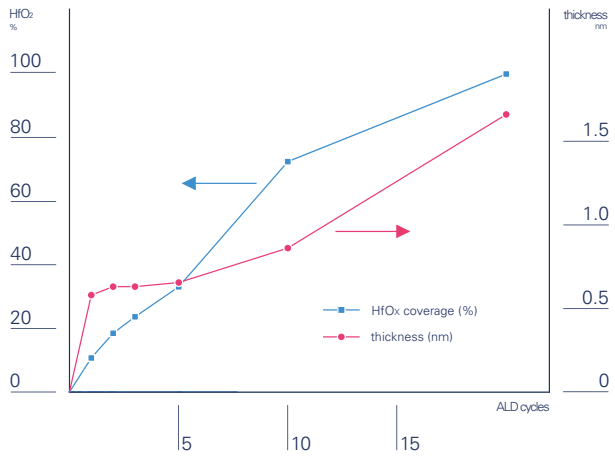
By using Ne^+ and Ar^+ in addition to He^+ scattering, the mass resolution for heavier elements is significantly enhanced.
Due to the high sensitivity of the unique Qtac analyzer, this is possible without detectable damage of the surface. In this way, all elemental pairs, even when close in mass like Ag/Pd and Pt/Au, can be resolved and quantified.

Time-of-Flight Filter

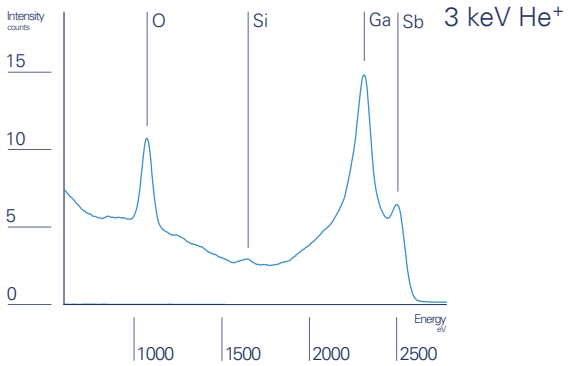
Applying a Time-of-Flight filter removes the background caused by sputtered ions from the LEIS spectra.
This significantly improves the detection limit, especially for light elements and when using heavier primary ions.

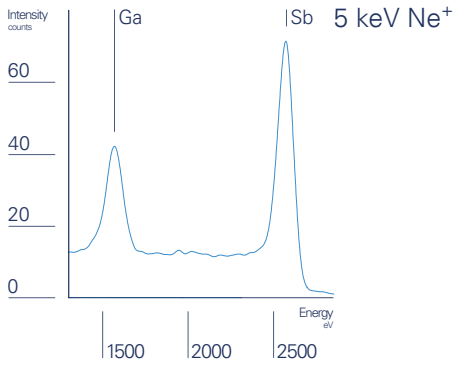


Series of LEIS spectra taken after an increasing number of ALD cycles for the deposition of HfO_2 on silicon

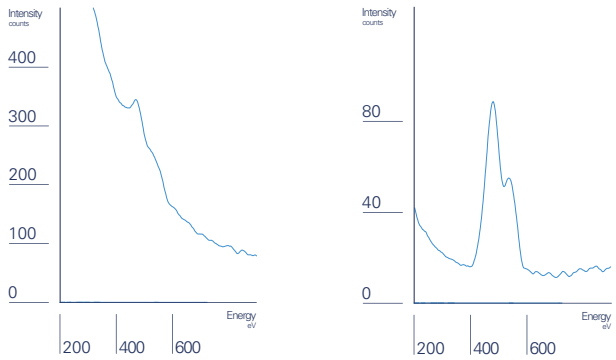


Measured HfO_x surface coverage and film thickness as a function of ALD cycles



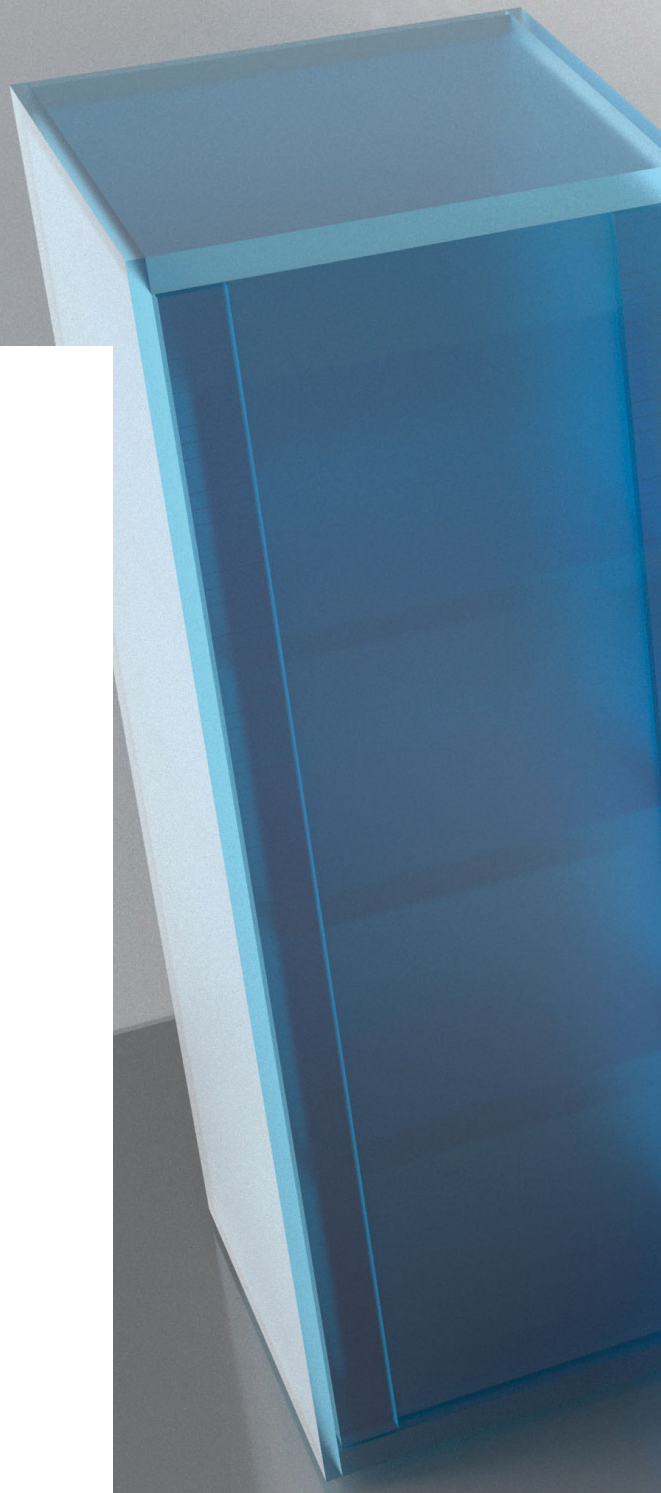


Spectra of incomplete GaSb ALD films on SiO_2



Static analysis of a Cu surface using Ar^+ scattering, with and without ToF filter (8 keV Ar^+, <1E13 ions/cm^2)

Customized Solution



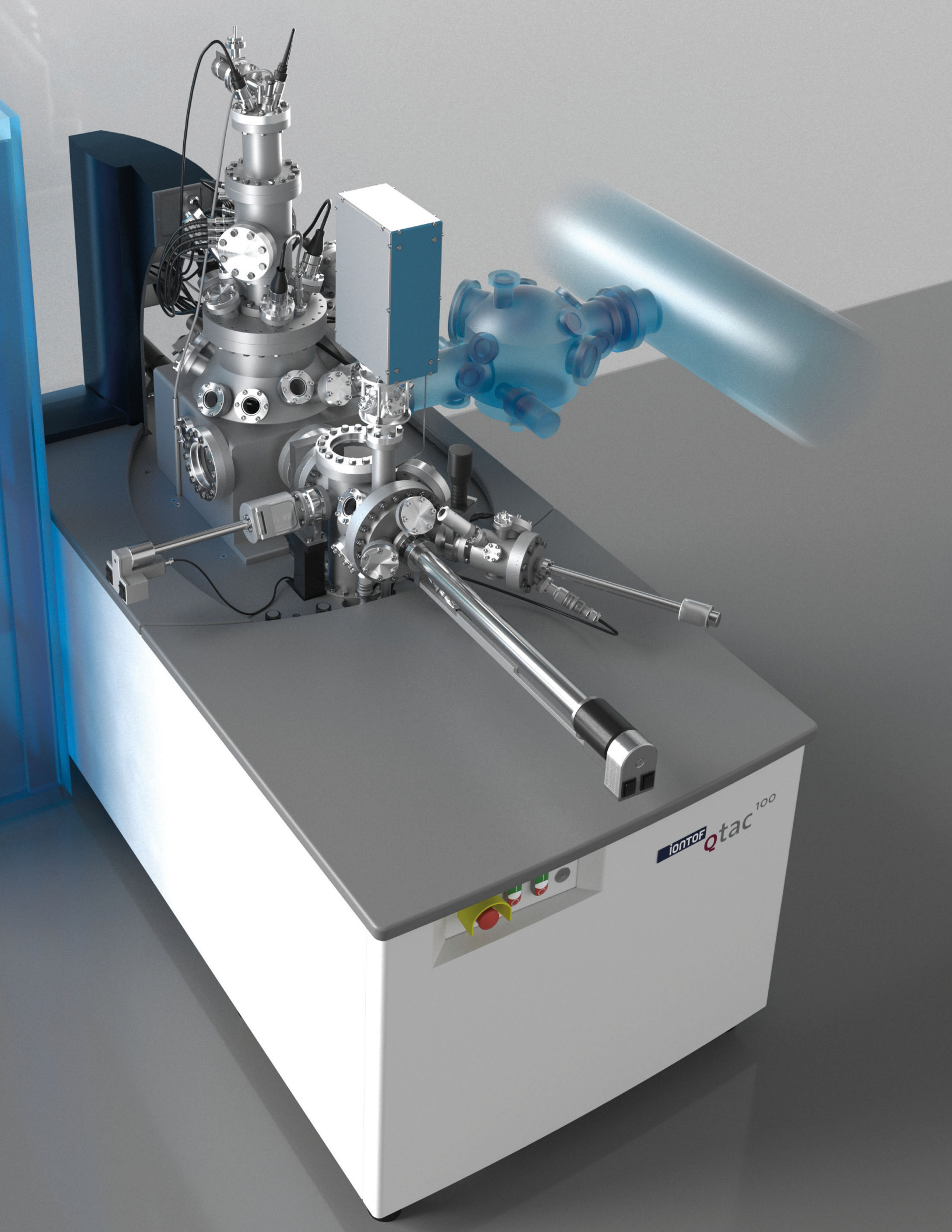
Close customer collaboration to meet individual needs

In laboratories with various analytical techniques, it is often beneficial to examine the same surface in more than one instrument, without exposing the sample to the atmosphere.

For many samples, e.g. from atomic layer deposition or catalyst preparation, in situ transfer between preparation and analysis is essential to monitor the undisturbed surface.

IONTOF has a strong tradition of collaboration with its customers to incorporate new ideas for hardware and software and to develop solutions for individual needs. The modular design of the Qtac's primary ion source and analyzer unit is ideal for this kind of customization.

A large variety of UHV chambers for sample preparation or additional characterisation techniques, designed by our experts for individual customers' specific requirements, can easily be added to the instrument. It is also possible to couple the instrument to existing UHV systems, or to integrate only the analytical component (Qtac bolt-on).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