Malvern Panalytical
a spectris company

X'PERT^3 MRD FAMILY

The proven choice for thin film analysis

DID YOU KNOW?
XRD characterization of thin film based devices is an important pillar during the manufacturing process. The X'Pert^3 MRD (XL) is for instance recognized by LED manufacturers worldwide as the leading solution.

Thin film analysis

ANALYTICAL X-RAY SOLUTIONS FOR **ALL TYPES OF THIN FILM**

Advancing materials research in thin films
Advancements in materials research have brought great changes to the way that we live. For example, materials technology has driven developments in communications that we now regard as a routine part of daily life. Thin film structures are at the heart of many advanced functional devices for electronic, optical, mechanical and energy applications.

Multi-layered materials
Growth technologies now allow the deposition of multi-layered structures with individual layers exhibiting thicknesses from microns down to monolayers. Typical materials that are involved in advanced thin film devices are semiconductors, metal alloys, dielectrics and polymers.

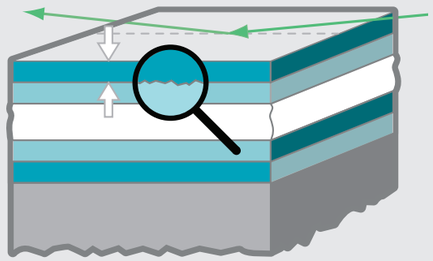
In all kind of thin film structures, multiple measurements are often required to investigate properties such as layer thickness, crystallographic phase and alloy composition, strain, crystallinity, density, and interface morphology.

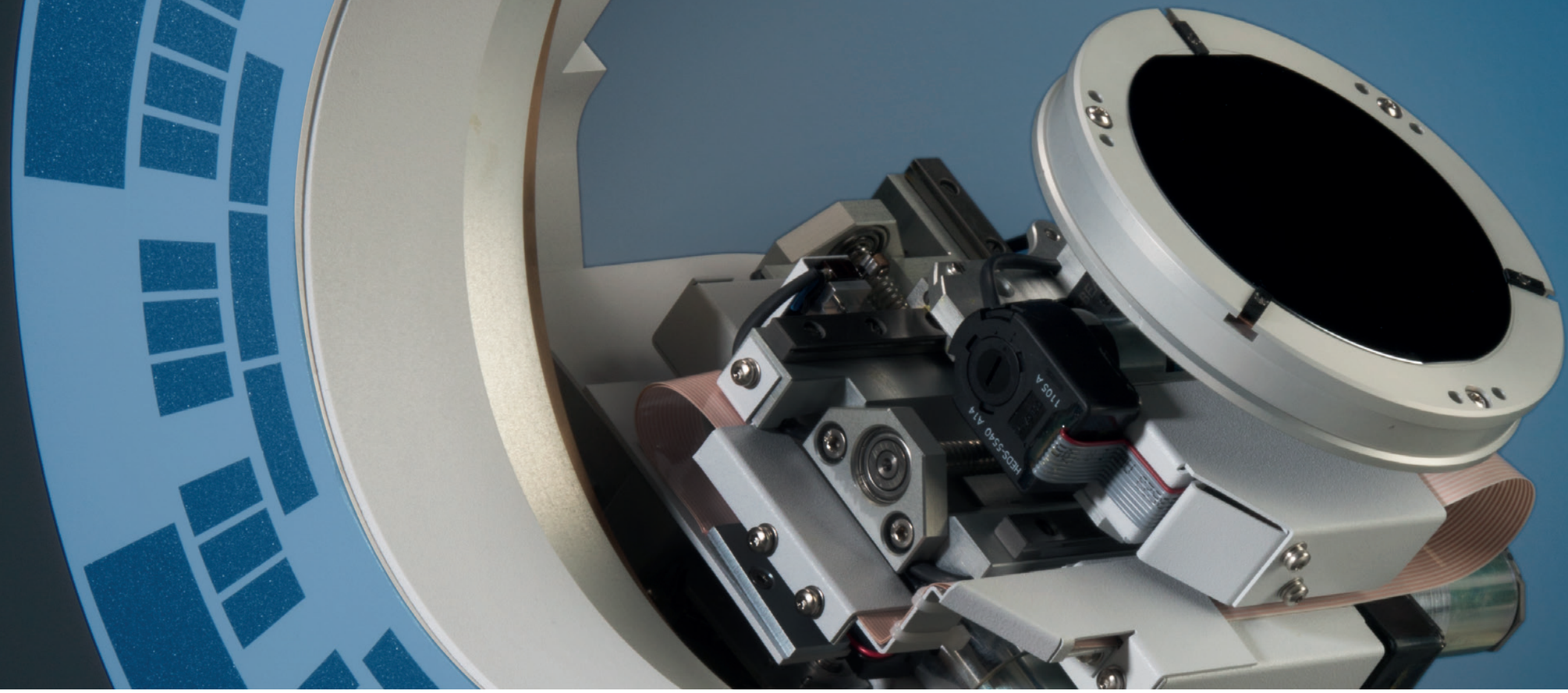
Investigating and monitoring structural properties
To design, understand and improve new devices, it is essential to measure key structural properties at every stage of the multi-step fabrication process. Monitoring layer properties is an essential step in research, development and production of thin film devices.

EXPLORING MATERIALS BY X-RAYS

X-ray diffraction methods are known to be non-destructive, accurate and versatile. They play an important part in the metrology of thin film structural parameters, bringing significant benefits to both materials research laboratories and thin film growth facilities.

The realization of these benefits requires that X-ray diffraction solutions offer flexibility and ease of use with all-in-one systems that can be tailored to suit the unique requirements of each customer.





LEADING IN ANALYSIS **OF THIN FILMS**

Pioneering high-resolution X-ray diffraction

Malvern Panalytical has a long and successful history in the m aterials analysis of thin films. Since the introduction of the first commercial high-resolution X-ray diffractometer in 1988, the company has continuously strengthened its position in high-resolution diffraction.

By working closely together with its customers, Malvern Panalytical has developed thin films solutions, suitable for a range of applications in both academic and industrial laboratories.

With over 20 years of experience in the provision of X-ray metrology of thin films, Malvern Panalytical has devevoped a large installed base worldwide and is a leading supplier to global LED producers.
In the thin film community Malvern Panalytical's Material Research Diffractometer (MRD) family has gained a reputation for reliability, versatility and high-resolution performance. The company continues to innovate, keeping the MRD up to date with the latest metrology requirements.

'The XRD equipment from Malvern Panalytical is vital to our work'.

- Producing GaN on Si LEDs, Dr. Sudhiranjan Tripathy at IMRE in Singapore

EXPLORING MATERIALS BY X-RAYS

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What has changed

Benefits

The X'Pert^3 MRD (XL) offers the benefit of improved performance and reliability. Maintaining its unrivalled precision and robustness, the new system delivers higher positioning and measurement speeds. Being compatible with most Malvern Panalytical XRD components across the product range, the X'Pert^3 MRD (XL) delivers more analytical capability and ensures its owner a future of optional enhancements and upgrades.

New features

These include:

- New high-resolution goniometer using Heidenhain encoders for improved accuracy and faster positioning feed-back time
- Rapid tool-free exchange of tube position from point to line focus
- System uptime, meeting process control demands thanks to pneumatic shutters and beam attenuators
- Longer lifetime of incident beam components with CRISP* including a lead-free tube tower
- Second generation of PreFIX for even more accurate optics positioning
- Future-proof single board computer controller for improved connectivity and extended remote support

*CRISP stands for corrosion resistant incident smart beam path. CRISP is a patented technology and prevents corrosion in the incident beam path caused by X-ray induced ionized air. Therefore results in more reliable operation and avoids additional maintenance.

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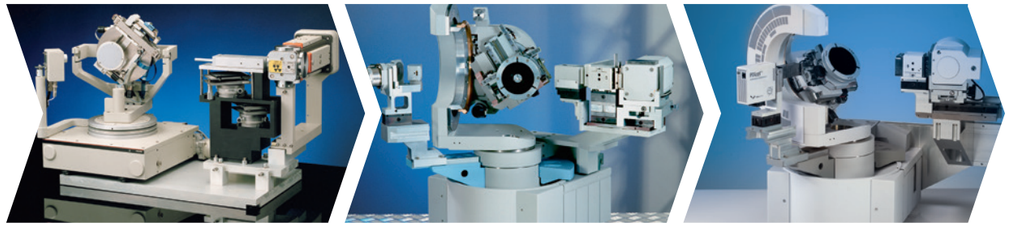
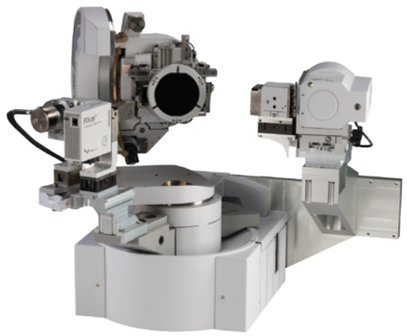


Succesful development of high-resolution diffractometers by Malvern Panalytical

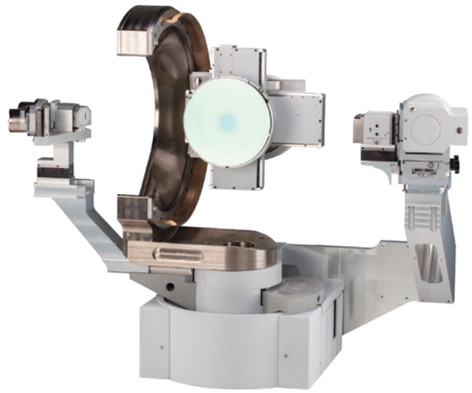
Precision and performance

SCALED TO SUIT **YOUR REQUIREMENTS**



X'Pert³ MRD

The X'Pert³ MRD has been specifically designed to meet the requirements of modern materials research and development laboratories. With a particular emphasis on thin film applications, the X'Pert³ MRD offers a variety of sample holders and can accommodate wafers up to 100 mm diameter, even for full mapping. Multiple samples can be mounted on its large sample platform.



X'Pert³ MRD XL

Sharing the same design and functionality as the X'Pert³ MRD, the X'Pert³ MRD XL is larger and has a strengthened cradle built to support oversized and heavy samples. The MRD XL offers self-centering wafer holders allowing for the mounting and alignment of wafers with diameters up to 300 mm.

The X'Pert³ MRD XL is ideal for a high-throughput environment. It can be extended with an automatic wafer loading robot with cassette-to-cassette handling and operating software that enables batch processing of wafers. In-wall mounting is possible for a tailor-made solution.

HIGHLY PRECISE AND STATE-OF-THE-ART PERFORMANCE

X'Pert³ MRD (XL) incorporates the latest technology in goniometer bearing design and position encoding resulting in an overall enhancement of performance. Innovations on the goniometer bearing have lead to improvements of stick slip behavior and exceptionally smooth rotation movement even at high load. The use of state-of-the-art Heidenhain optical encoders on both the omega and 2theta axes have enabled both short-range and long-range accuracy improvements and have increased the speed in both position reporting and goniometer positioning.

SAMPLE PLATFORM

The X'Pert³ MRD and X'Pert³ MRD XL Eulerian cradles offer highly precise and reproducible, unobstructed movements for sample rotation, tilt and x-, y- and z- translations, ensuring versatile and accurate sample positioning for the most demanding XRD applications.

Adapting to new requirements

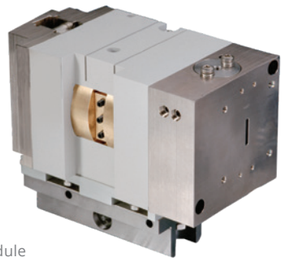
EASILY UPGRADABLE AND **YOUR REQUIREMENTS**

PreFIX

Malvern Panalytical's proprietary PreFIX (Pre-aligned Fast Interchangeable X-ray items) concept enables the MRD (XL) to be reconfigured without realignment. New PreFIX components can easily be added when experimental requirements change, making it flexible, fast and future-proof.

An extensive range of PreFIX modules are available including:

- X-ray parallel mirrors
- Hybrid monochromators
- High-resolution four crystals monochromators
- Polycapillary lens
- Programmable and fixed divergence and anti-scatter slits
- Crossed slits and monocapillaries



PreFIX module

Continuous evolution

Malvern Panalytical's portfolio of detectors is continuously evolving. Specific benefits in semiconductor and thin film applications are achieved by the PIXcel^{3D} detector which offers full versatility and allows for superior dynamic range measurements without the need for beam attenuation.

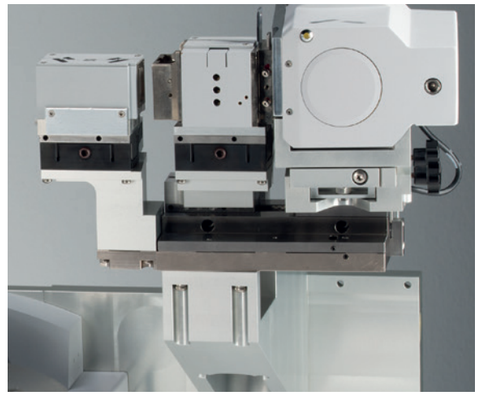
The PIXcel detector can be used for all applications and can be effortlessly switched from 0D receiving slit mode to 1D and 2D static and scanning modes.

PIXcel^{3D}

Freedom and flexibility

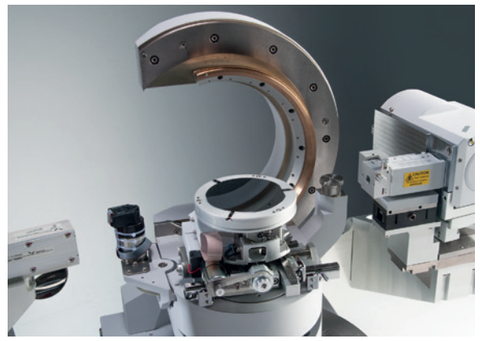
Both the X'Pert^3 MRD and the X'Pert^3 MRD XL are available with an extended arm option to hold two PreFIX optics. This gives the user the freedom and flexibility to use key optical components to boost performance.

In the example shown below, the addition of a mirror on the extended arm boosts the intensity from a monochromator by a factor of 10 with no loss in resolution.



At the touch of a button

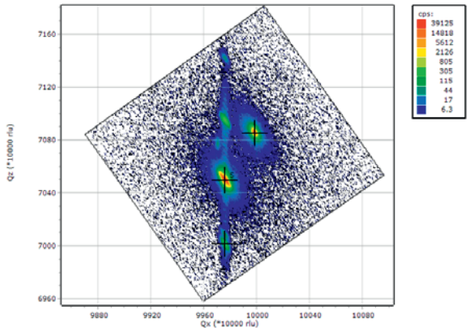
Both the X'Pert^3 MRD and the X'Pert^3 MRD XL can be adapted for in-plane diffraction of surface layers. The large angular ranges of the Eulerian cradle and the goniometer enable the in-plane configuration to be established at the touch of a button.



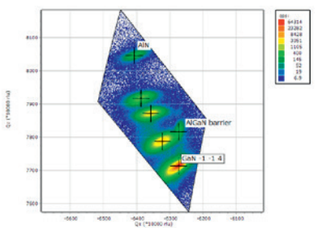
Software that works for you

INTELLIGENT MEASUREMENT

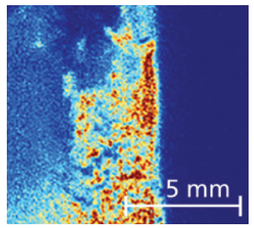
Drawing on decades of experience in XRD metrology, Malvern Panalytical has developed, and continues to improve, its cross-platform Data Collector software. Robust and well supported, the Data Collector software offers maximum freedom and control whilst ensuring safety and performance. Rigorously tried and tested, pre-programmable and batch-friendly, Data Collector continues to work for you, tirelessly, night and day, so that you can use your time effectively.



A high-resolution reciprocal space map collected using the triple bounce analyzer and a detector in 0D mode



Ultra-fast reciprocal space map collected using a 2D detector in continuous mode



A topography image collected using a detector in 2D mode

User-focused software

Malvern Panalytical's Data Collector control software enables the creation of individual user accounts with saved configurations and batch programming.

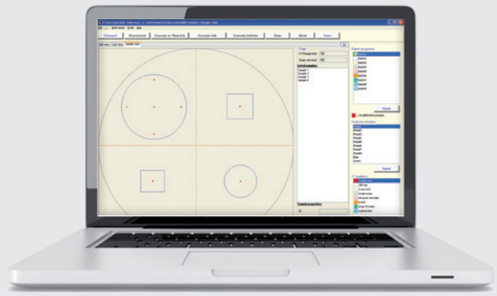
Alignment and measurement procedures can be seamlessly automated. The software helps with measurement design, data viewing and data conversion for export. Measurement results are interchangeable with other systems for data transfer and file sharing.
Full flexibility of detector modes allows the user freedom to design experiments to suit individual requirements. For example, triple bounce analyzer (TA) high-resolution reciprocal space maps with a detector in 0D mode offer the highest sensitivity.
Rapid reciprocal space mapping (RSM) can be achieved with a detector in 1D scanning or static mode offering medium resolution at high speeds. With the PIXcel^{3D} detector RSMs can be collected in acquisition times similar to rocking curves. Topography using 2D imaging mode provides an instant picture of wafer quality.

Towards automatic analysis

Additionally, the Automatic Program Processing software (APP) provides a mechanism to trigger the automatic analysis of data, using Malvern Panalytical or other analysis software. Malvern Panalytical offers a range of analytical packages covering applications from high-resolution epitaxial thin film to polycrystalline phase analysis.

AUTOMATION

The Operator Interface software addition is used to define and execute pre-programmed job lists for wafer cassettes and multiple wafer chucks. It provides status feedback and time-to-go information together with messenger notification.



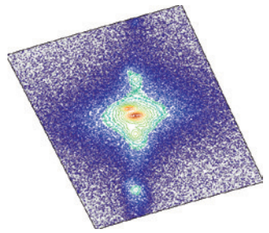
AN ALL-IN-ONE **X-RAY SOLUTION SYSTEM**

Applications

SEMICONDUCTORS AND SINGLE CRYSTAL WAFERS

Whether for growth studies or device design, the measurement of layer quality, thickness, strain and alloy composition using high-resolution XRD has been at the heart of research and development in electronic and optoelectronic multilayer semiconductor devices.

With a choice of X-ray mirrors, monochromators and detectors, the X'Pert^3 MRD and MRD XL offer high-resolution configurations to suit different materials systems ranging from lattice matched semiconductors, through relaxed buffer layers on to novel exotic layers on non-standard substrates.

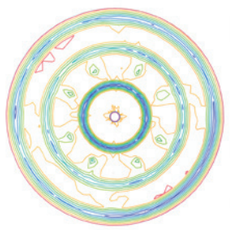


Reciprocal space exploration

POLYCRYSTALLINE SOLIDS AND THIN FILMS

Polycrystalline layers and coatings are an important component of many thin films and multilayer devices. The evolution of polycrystalline layer morphology during deposition is a key study area in functional materials research and development.

X'Pert^3 MRD and X'Pert^3 MRD XL can be fully equipped with a range of slits, parallel beam X-ray mirror, polycapillary lens, crossed slits and mono-capillaries to give the full choice of incident beam optics for reflectometry, stress, texture and phase ID.

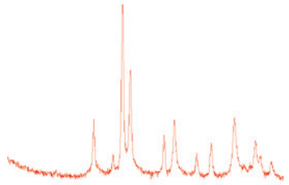


Texture analysis

ULTRA-THIN FILMS, NANOMATERIALS AND AMORPHOUS LAYERS

Functional devices may contain disordered, amorphous or nanocomposite thin films. The flexibility of the X'Pert^3 MRD and MRD XL systems allow for the incorporation of multiple analytical methods.

A range of high-resolution optics, slits and parallel plate collimators are available to give the optimum performance for grazing incidence methods, in-plane diffraction and reflectometry.

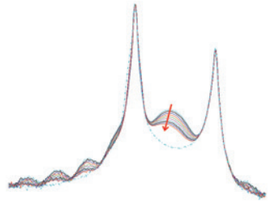


Grazing incidence phase identification

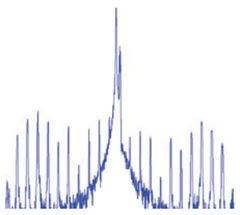
MEASUREMENT UNDER NON-AMBIENT CONDITIONS

Studying the behavior of materials under a variety of conditions is an essential part of materials research and process development.

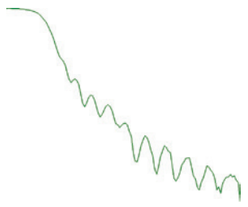
The X'Pert^3 MRD and MRD XL are designed for the easy incorporation of the DHS1100 non-ambient sample stage from Anton Paar, enabling automated measurementsunder a range of temperatures and inert atmosphere.



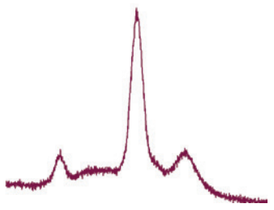
Temperature and time dependent peak height change



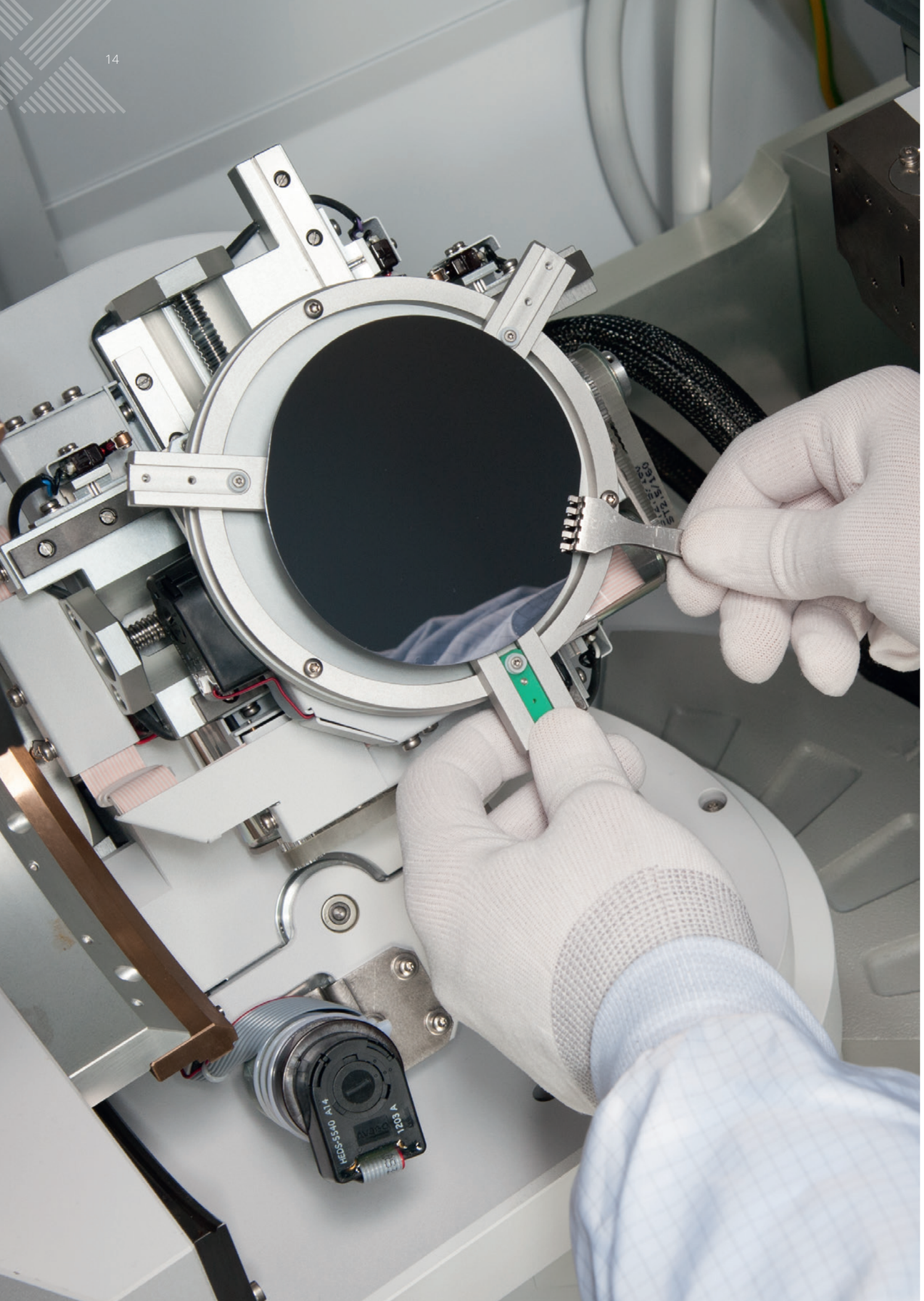
Rocking curve analysis



Reflectometry



In-plane diffraction



X'PERT^3 FAMILY

Enclosure

Specifications	
Dimensions	1972 mm H x 1370 mm W x 1131 mm D
Weight	1150 kg (instrument only)
X-ray safety	Less than 1µSv/h at 10 cm distance from the outside surface of the enclosure
Safety standards	Compliance with Machine Directive 2006/42/EC and EMC Directive 2004/108/EC. Declaration conformity with every instrument.
Compressed air supply	House line, compressor or air bottle; 2-5 bar (0.2 - 0.5 MPa)

X-ray generation

Specifications	
Anode materials	Cu, Co, Cr, other (Mo,....) on request
Focus size	0.4 mm x 12 mm (LFF)
Construction X-ray tube	Ceramic insulation
Tube housing	The tube house is Pb free. Patented design with CRISP* technology. CRISP technology prevents corrosion in the incident beam path caused by X-ray induced ionized air. Patent no. US 8437451 B2
Line/point focus switching	Standard feature, tool free
Shutter	Pneumatic
X-ray generator	3 kW

Detector

Specifications	
Type	Proportional, Xe-filled
Window size	24 x 20 mm^2
Linear countrate, maximum	1.000.000 cps
Background noise, maximum	<0.5 cps
Lifetime, minimum	10^{13} counts
Type	Solid state, 256 x 256 pixels (each 55 x 55 µm^2)
Window size	14 x 14 mm^2
Linear countrate, maximum	13.000.000 cps per column
Background noise, maximum	<0.002 cps per column <0.5 cps total

Malvern Panalytical
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WHY CHOOSE **MALVERN PANALYTICAL**?

We are global leaders in materials characterization, creating superior, customer-focused solutions and services which supply tangible economic impact through chemical, physical and structural analysis.

Our aim is to help you develop better quality products and get them to market faster. Our solutions support excellence in research, and help maximize productivity and process efficiency.

Malvern Panalytical is part of Spectris, the productivity-enhancing instrumentation and controls company.

www.spectris.com

SERVICE & **SUPPORT**

Malvern Panalytical provides the global training, service and support you need to continuously drive your analytical processes at the highest level. We help you increase the return on your investment with us, and ensure that as your laboratory and analytical needs grow, we are there to support you.

Our worldwide team of specialists adds value to your business processes by ensuring applications expertise, rapid response and maximum instrument uptime.

- Local and remote support
- Full and flexible range of support agreements
- Compliance and validation support
- Onsite or classroom-based training courses
- e-Learning training courses and web seminars
- Sample and application consultancy

www.malvernpanalytical.com/xpert3

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