



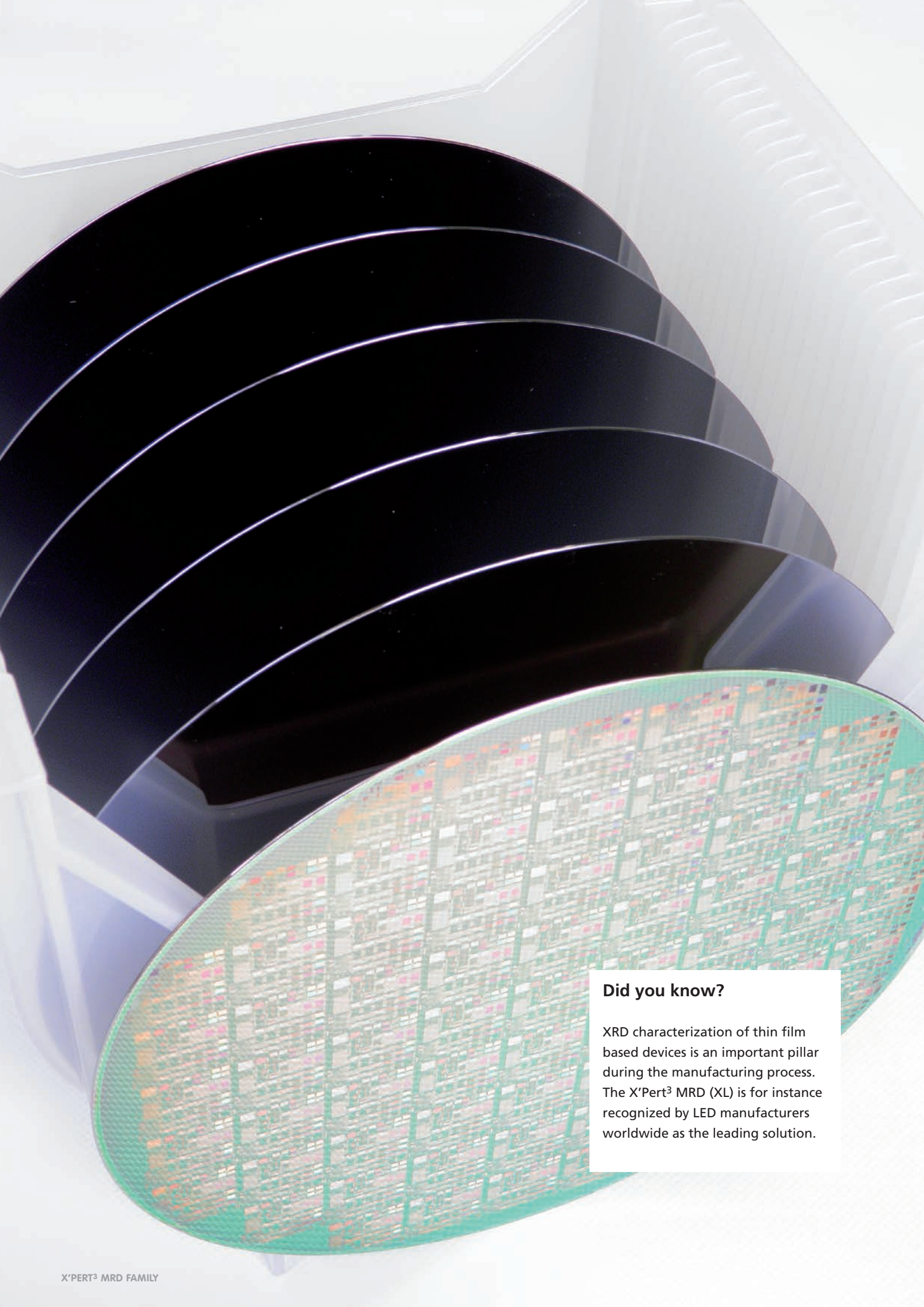
PANalytical
get insight



X'PERT³ 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'Pert³ MRD (XL) is for instance recognized by LED manufacturers worldwide as the leading solution.

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.



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.

Multi-layered materials

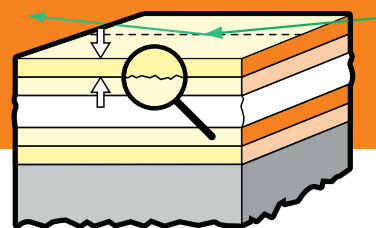
Growth technologies now allow the deposition of multi-layered structures with individual layers exhibiting thicknesses from microns down to monolayers. Typical materials that are involved in advanced thin film devices are semiconductors, metal alloys, dielectrics and polymers.

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.



Leading in analysis of thin films

PANalytical has a long and successful history in the materials 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, 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, PANalytical has developed a large installed base worldwide and is a leading supplier to global LED producers.

In the thin film community 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 PANalytical is vital to our work'.

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

A success story continues

Building on a successful history and driven to meet the new technology requirements, PANalytical introduces the X'Pert³ MRD and MRD XL. These systems continue to offer all-in-one solutions that can be easily configured to fulfill the unique requirements of different measurements and can be easily adapted to the user's knowledge and skills.



What has changed

Benefits

The new X'Pert³ 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 PANalytical XRD components across the product range, the X'Pert³ 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.*

Successful development of high-resolution diffractometers by PANalytical



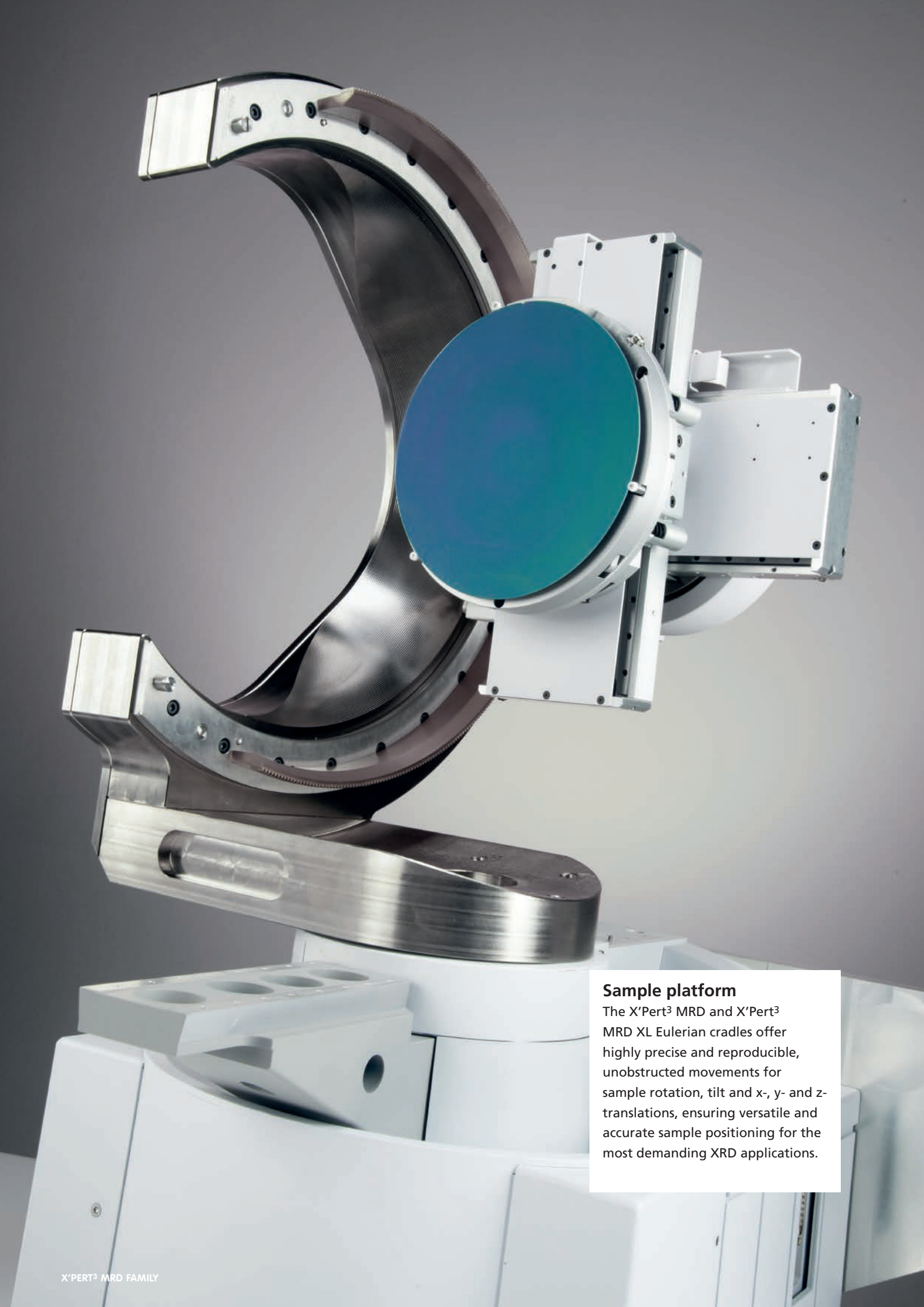
1988



1999



2014



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.

Scaled to suit your requirements



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.



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 led 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.



Easily upgradable and future

1 PreFIX

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

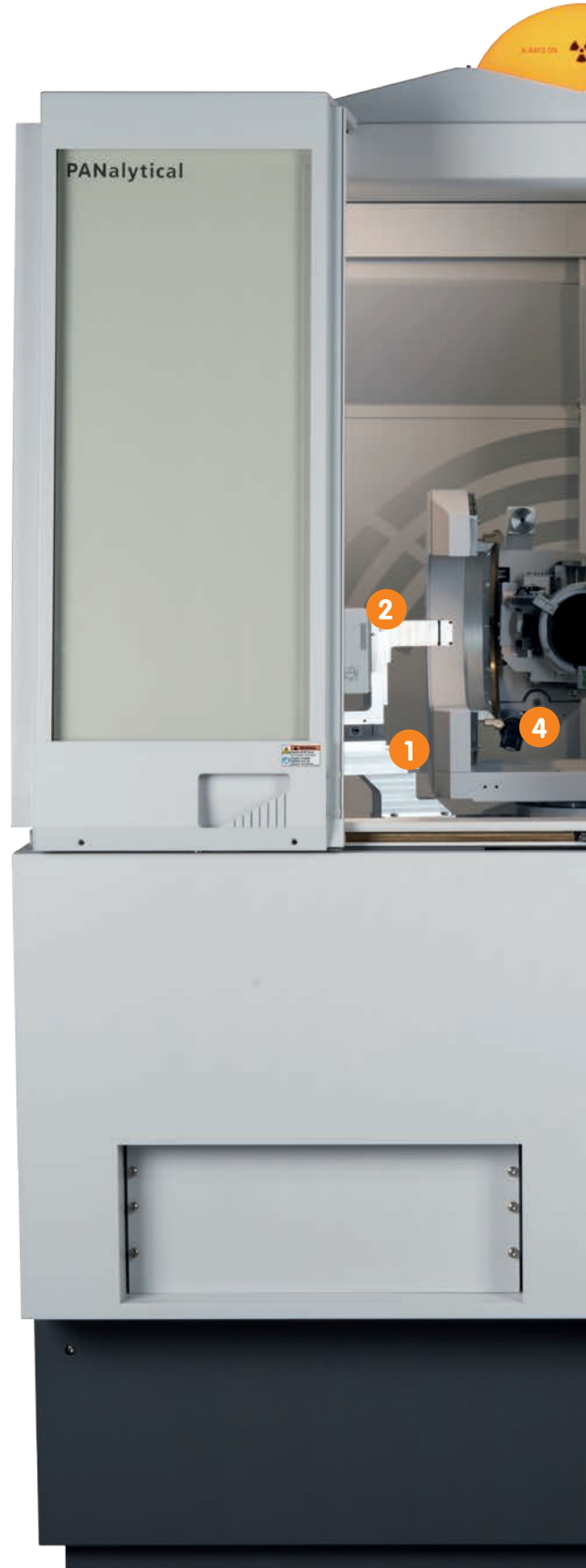


2 Continuous evolution

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}



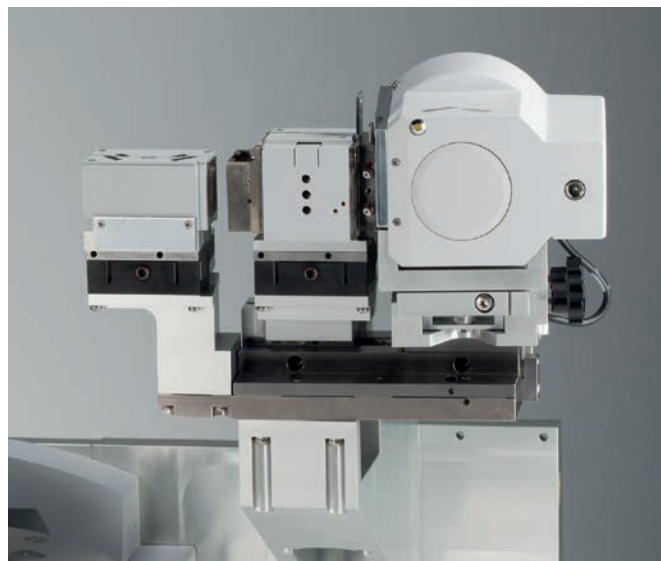
ure-proof



3 Freedom and flexibility

Both the X'Pert³ MRD and the X'Pert³ 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.



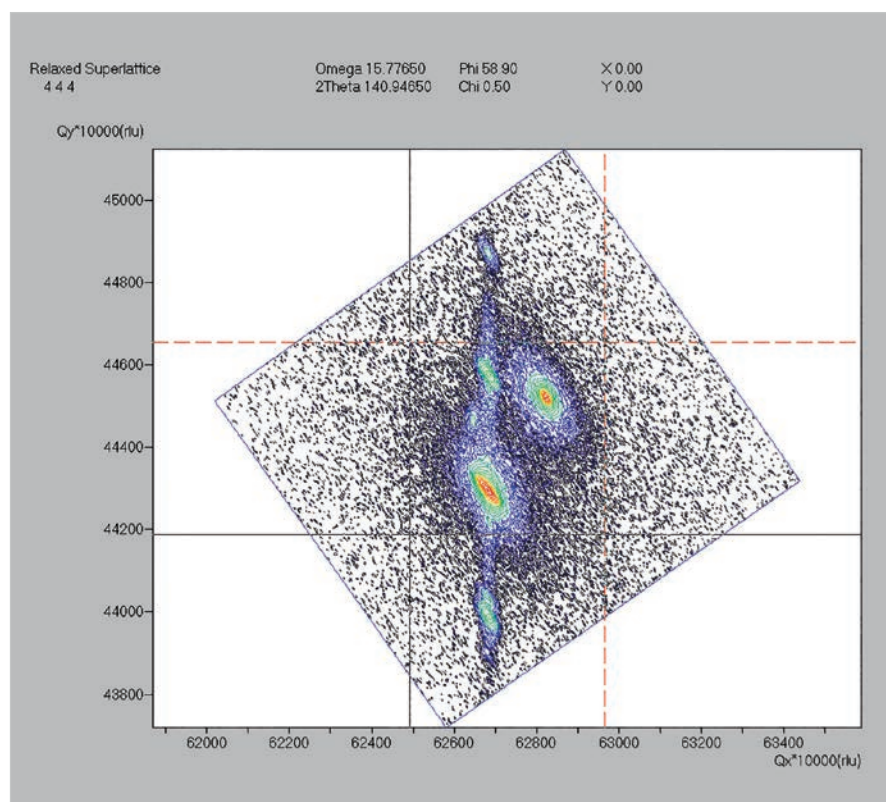
4 At the touch of a button

Both the X'Pert³ MRD and the X'Pert³ 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.

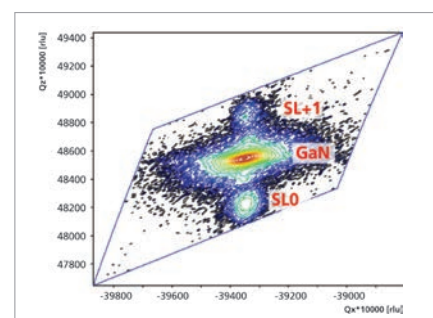


Intelligent measurement

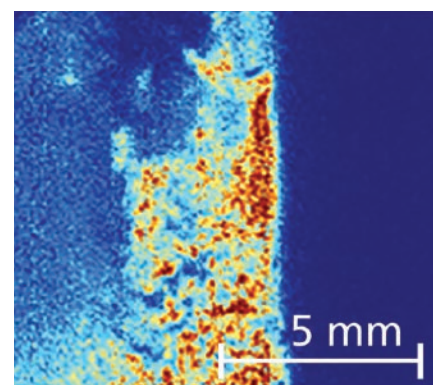
Drawing on decades of experience in XRD metrology, PANalytical has developed, and continues to improve, its cross-platform Data Collector software. Robust and well supported, the Data Collector software offers maximum freedom and control whilst ensuring safety and performance. Rigorously tried and tested, 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



A rapid reciprocal space map collected using a 1D detector in static mode



A topography image collected using a detector in 2D mode

User-focused software

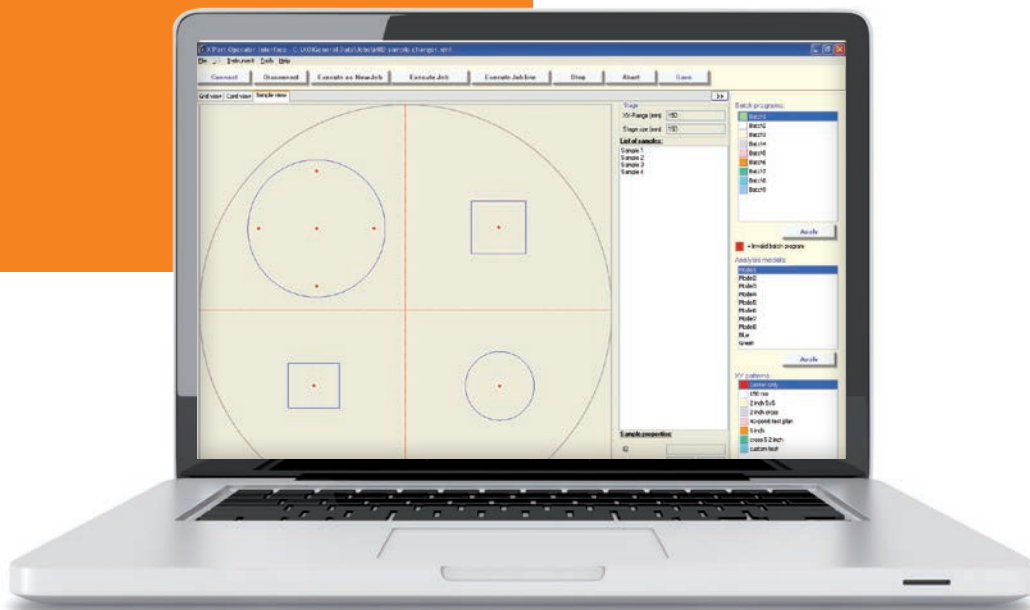
PANalytical's Data Collector control software enables the creation of individual user accounts with saved configurations and batch programming. Alignment and measurement procedures can be seamlessly automated. The software helps with measurement design, data viewing and data conversion

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 can be achieved with a detector in 1D scanning or static mode offering medium resolution at high speeds. Topography using 2D imaging mode provides an instant picture of wafer quality.

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.



Towards automatic analysis

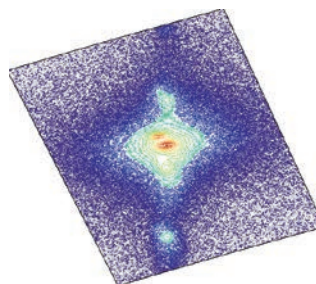
Additionally, the Automatic Program Processing software (APP) provides a mechanism to trigger the automatic analysis of data, using PANalytical or other analysis software. PANalytical offers a range of analytical packages covering applications from high-resolution epitaxial thin film to polycrystalline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

An all-in-one X-ray solution system

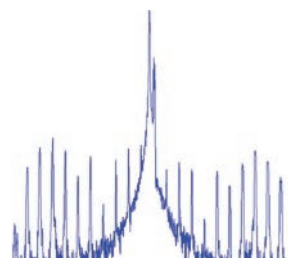
Semiconductors and single crystal wafers

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'Pert³ 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

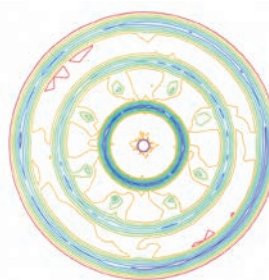


Rocking curve analysis

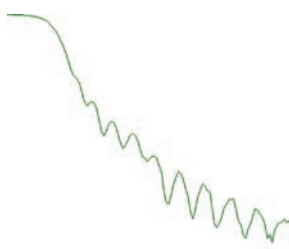
Polycrystalline solids and thin films

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'Pert³ MRD and X'Pert³ MRD XL can be fully equipped with a range of slits, parallel beam X-ray mirror, polycapillary lens, crossed slits and monocapillaries to give the full choice of incident beam optics for reflectometry, stress, texture and phase ID.



Texture analysis

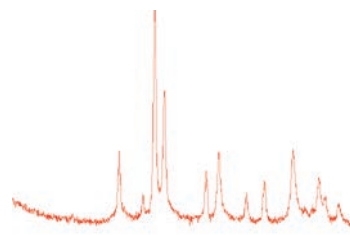


Reflectometry

Ultra-thin films, nanomaterials and amorphous layers

Functional devices may contain disordered, amorphous or nanocomposite thin films. The flexibility of the X'Pert³ 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

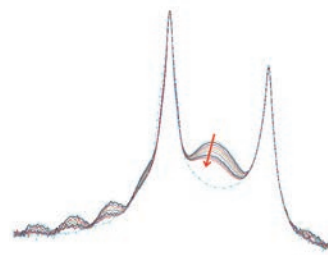


In-plane diffraction

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'Pert³ MRD and MRD XL are designed for the easy incorporation of the DHS1100 non-ambient sample stage from Anton Paar, enabling automated measurements under a range of temperatures and inert atmosphere.



Temperature and time dependent peak height change

Your partner every step of the way

When buying an instrument from PANalytical application and service support is always nearby. PANalytical is present globally and has application laboratories in the Netherlands, USA, Brazil, China and Japan.

Together with your input, PANalytical is able to continuously develop and innovate. When you invest in PANalytical, you invest in a relationship that is built to last.

Research and development

PANalytical takes pride in designing solutions. In-house research and development, from the X-ray tubes, goniometer and cradle through to detectors and analysis software, allow us to adapt the MRD (XL) to the user's requirements through all stages of the design.



PANalytical Award

PANalytical not only supports its clients, but also seeks to encourage excellent young scientists who are at the beginning of their careers. The PANalytical Award recognizes and praises groundbreaking research that exploits one or more laboratory-based X-ray scattering methods.

Knowledge center

For answers to any kind of questions, we offer webinars or application notes in the knowledge center on our website. Here you have premium articles on X-ray technology at your fingertips. Access various application notes, articles, white papers and more via www.panalytical.com/Knowledge-overview.htm

Courses

PANalytical offers on-site training and customer courses around the globe. Courses on basic XRD, high-resolution diffractometry and reflectometry are just a few examples. See www.panalytical.com/courses for more details.



About PANalytical

PANalytical's mission is to enable people to get valuable insight into their materials and processes. Our customers can be found in virtually every industry segment, from building materials to pharmaceuticals and from metals and mining to nanomaterials. The combination of our software and instrumentation, based on X-ray diffraction (XRD), X-ray fluorescence (XRF), near-infrared (NIR) and optical emission (OES) spectroscopy and pulsed fast thermal neutron activation (PFTNA), provides our customers with highly reliable and robust elemental and structural information on their materials and is applied in scientific research and industrial process and quality control.

PANalytical employs over 1,000 people worldwide. The company's headquarters are in Almelo, the Netherlands. Fully equipped application laboratories are established in Japan, China, the US, Brazil, and the Netherlands. PANalytical's research activities are based in Almelo (NL) and on the campus of the University of Sussex in Brighton (UK). Supply and competence centers are located on two sites in the Netherlands: Almelo (development and production of X-ray instruments) and Eindhoven (development and production of X-ray tubes), in Nottingham, UK (development of XRF applications and standards) and in Boulder CO, US (development and production of near-infrared instruments).

PANalytical is active in all but a few countries of the world. This worldwide sales and service network ensures unrivalled levels of customer support.

The company is certified in accordance with ISO 9001 and ISO 14001. Visit www.panalytical.com for more information about our activities.

PANalytical is part of Spectris plc, the productivity-enhancing instrumentation and controls company.

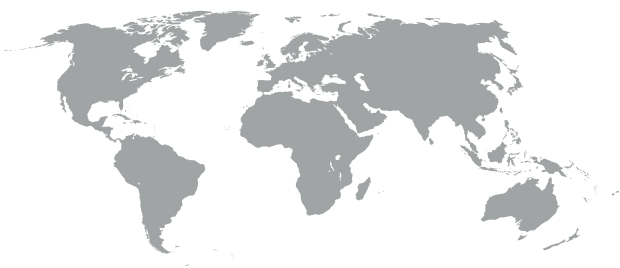
Access to expertise

With the largest service network we are able to offer the most comprehensive support package possible.

Expertise:

- On-site training
- XRF and XRD training courses
- Performance optimization
- Customizable expertise programs
- Assistance with multi-laboratory standardization

Global and near



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