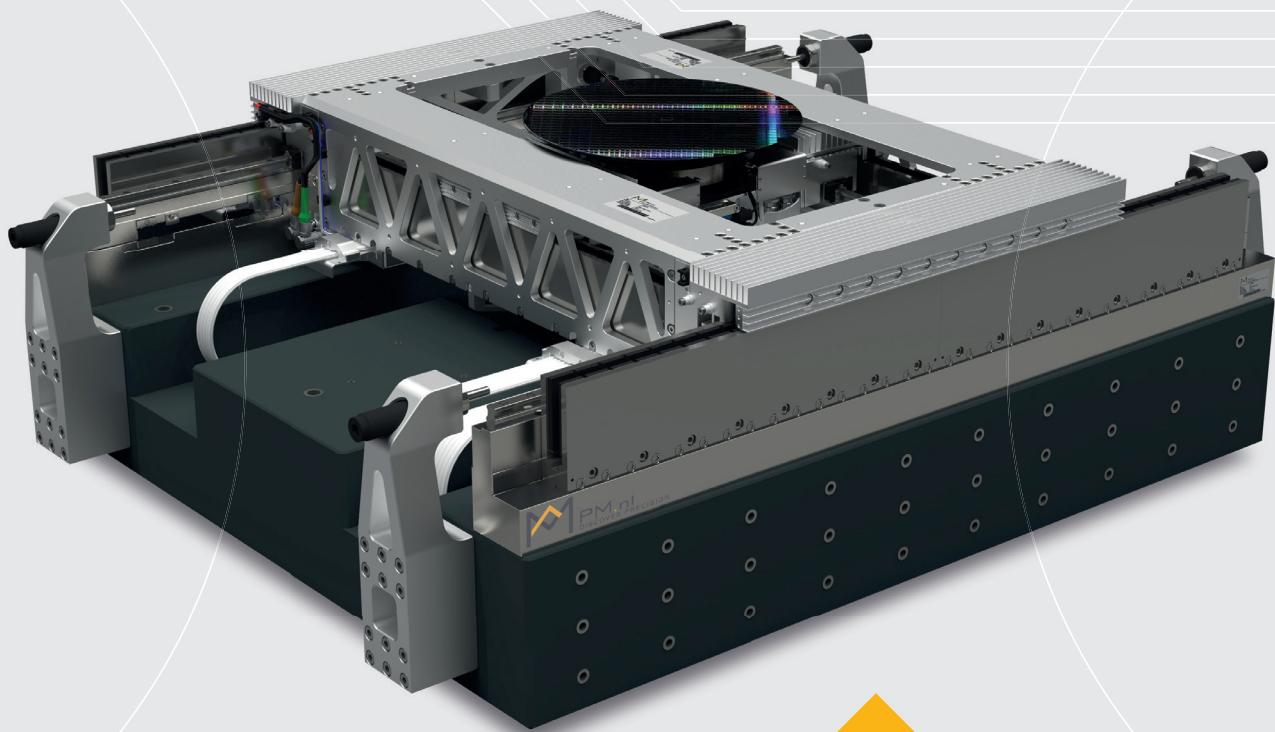


ENGINEERED-TO-SPEC MOTION SYSTEMS



COMPETENCES



INTRODUCTION



PM is a high-end bearing and (mechatronic)system supplier, offering full vertical integration from (co-) engineering to production, assembly and qualification, all performed in-house. With a long history spanning over 55 years, PM stands out through its ability to supply customised and complex products within a short timeframe. For selected OEM customers, PM is a preferred technology partner, working closely to develop precision motion products for new applications. This enables customers who rely on state-of-the-art products to maintain their position as industry leaders.

PM's flexible approach and expertise allows to design, manufacture and integrate complex motion systems with relatively short lead times.



Linear bearing manufacturing is one of PM's core competencies. The expertise begins in the company's R&D centre, located within the manufacturing facilities in Dedemsvaart, the Netherlands. New products are designed, simulated, and tested before being launched to the market. Modern design and simulation software enables PM to ensure consistent high product quality, before manufacturing starts.





MANUFACTURING EXPERTISE

VERTICAL MANUFACTURING INTEGRATION

PM has unmatched in-house manufacturing expertise. This know-how allows the company to offer exceptional flexibility while ensuring consistently high product quality. Every step in the manufacturing process is carefully controlled.

One of PM's key advantages is the ability to implement design changes quickly and integrating them seamlessly into the manufacturing processes to maintain the shortest possible lead times.

Thanks to its deep vertical integration, PM provides greater accountability, enhanced flexibility, lower costs and a single point of contact throughout the project.

MANUFACTURING

PM's manufacturing plant is equipped with modern machinery for a wide range of operations, including:

- Turning
- Milling
- Drilling
- Heat treatment
- Lapping & Polishing
- Electrochemical machining
- Flat & cylindrical grinding
- High-purity cleaning & inspection
- Bake-out
- RGA analysis

With its extensive range of machinery, PM has in-house manufacturing capacity for all critical components. Stage assemblies, modules, frames, cabinets, holders, and vacuum chambers for motion systems are all produced internally. This internal manufacturing capability gives PM full control over the entire production process, ensuring meticulous attention to detail and the highest level of quality.

LARGE-SCALE PRECISION MACHINING



For the manufacturing of motion system related products, PM offers ultra-large machining capabilities. Vacuum chambers, accurate machine frames and structural components as large as 10.5 x 3 x 1.3 metres (L xW x H) can be machined.

VACUUM PREPARATION



For products which operate in vacuum environments, PM offers comprehensive cleaning services to ensure the highest level of cleanliness. These include bake-out processes and Residual Gas Analysis (RGA) to effectively remove contaminants and verify vacuum compatibility, before starting assembly in a cleanroom.

QUALIFICATION FOR EXCELLENT PRODUCTS



For both component and motion system qualification, PM has inspection equipment in-house. This guarantees that only products which meet all specifications are shipped. Examples of available measuring equipment include:

- 3D coordinate measuring machines (CMM)
- Surface inspection microscopes
- High-resolution laser interferometers
- Capacitive displacement sensors
- Autocollimators
- Vibrometers

In addition to advanced inspection equipment, PM follows a structured qualification process to ensure full compliance with customer requirements. This process includes:

- Use of calibrated inspection equipment
- First Article Inspection (FAI)
- Intermediate and final inspections
- Comprehensive measurement reports
- Full documentation and traceability



TECHNOLOGY EXPERTISE

DESIGN AND ENGINEERING EXPERTISE

PM's engineers in R&D, design and production bring deep application knowledge. They combine engineering and manufacturing expertise to deliver sub-micron motion solutions. Tools commonly used include:

- PLM software with Teamcenter integration
- CAD software (NX)
- MATLAB
- FEA tools for structural, dynamic, thermal and flow analysis
- Topology optimisation
- Collaborative change management
- Motion control modelling
- Magnetic shielding simulation

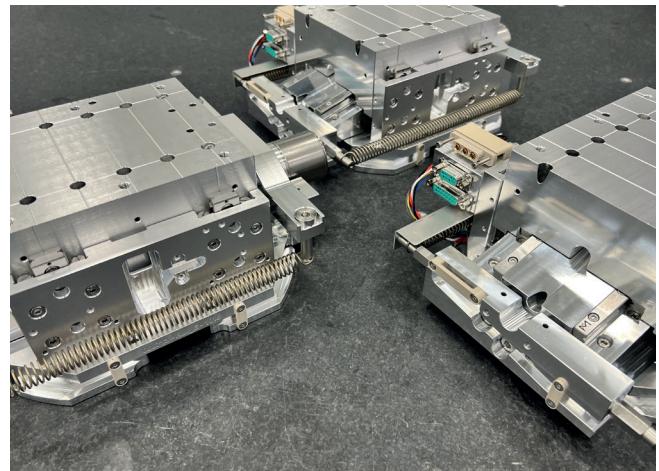


LINEAR BEARING AND ROTATING BEARINGS

With over 55 years of expertise, PM manufactures precision linear and rotary bearings for motion systems. Standard and customised configurations are available to suit specific application needs. The company offers best-in-class products, with both standard and customised options available to meet customer requirements. Additional technologies offered include:

- **SF-class technology:** An optional feature that delivers unmatched surface quality in linear bearings. Rail surface roughness is reduced to $< 0.05 \text{ Ra}$, enabling smooth, precise motion for applications such as scanning and measuring.
- **Anti-Cage Creep (ACC) technology:** A robust and reliable solution for high-dynamic applications. ACC eliminates cage drift and keeps the cage perfectly centered, even under extreme dynamic conditions and in every mounting direction.

VACUUM EXPERTISE



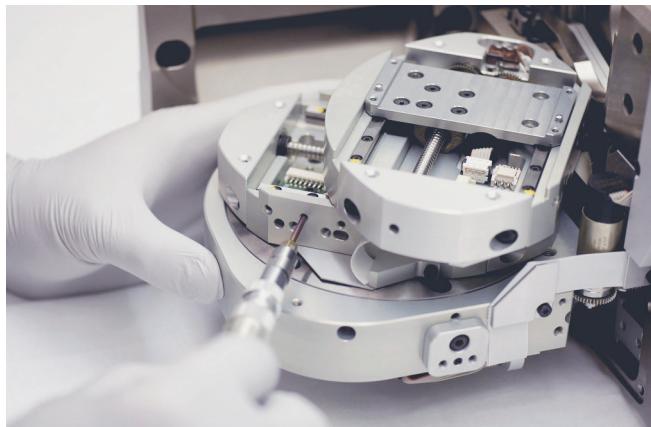
In industries such as medical technology, photonics, semiconductors and life sciences, an increasing number of processes must be performed under vacuum conditions. PM manufactures precision linear bearings and motion systems for applications such as Scanning Electron Microscopy, Electron Beam Processing, EUV Lithography, Electron Beam Lithography, Focused Ion Beam Systems and other advanced high-tech processes.

PM provides extensive expertise in motion systems designed for various vacuum environments. Available capabilities include:

- Material selection
- Design considerations, including vented holes, integrated venting paths or slots
- Lubricant selection
- Motor and encoder component selection
- Various cleaning processes
- Bake-out procedures
- Surface finishing for vacuum compatibility
- Residual Gas Analysis (RGA)
- Leak detection
- UV-cleanliness inspection
- Cleanroom assembly
- Testing and qualification
- Blacklight inspection
- Custom sealing and shielding solutions
- Magnetism control / non-magnetic options
- Vacuum dedicated packaging



DRIVE TECHNOLOGY EXPERTISE



For the selection of drive mechanisms, encoders, cables and switches, such as linear, piezoelectric, DC and stepper motors, PM relies on long-term expertise. Component selection is based on, but not limited to, factors such as stroke, velocity, resolution and load requirements.

NON-MAGNETIC EXPERTISE

In 2005, PM was the first linear bearing manufacturer to realise the practical use of ceramic linear bearings in high-precision motion systems operating under extreme conditions. These products are used in applications requiring low magnetic permeability or high-temperature operation.

The most popular ceramic materials include:

- Silicon Nitride (Si_3N_4)
- Alumina (Al_2O_3)
- Zirconia (ZrO_2)

For motion systems requiring minimal magnetic interference, PM applies non-magnetic materials and integrates shielding at specific locations where needed.



CLEANROOM EXPERTISE

High-tech applications in various industries demand assembly conditions with strictly controlled particle contamination. To meet these demands, PM provides certified ISO Class 6 and Class 7 cleanroom facilities and assembly cells, fully compliant with ISO 14644-1 standards. All parts and products remain within the cleanroom environment until they are fully qualified and securely packaged.





ENGINEERING COMPETENCES

PM combines over five decades of experience with advanced technical capabilities to deliver high-performance motion systems and components. The engineering team applies a multidisciplinary approach, ensuring that each system meets the highest precision, stability and functional requirements.

OUR EXPERTISE

- Systems engineering
- Advanced mechatronics
- Dynamics and control
- Precision engineering
- Thermal management
- Bearing stiffness calculation
- Magnetic shielding and simulation
- Supply chain management

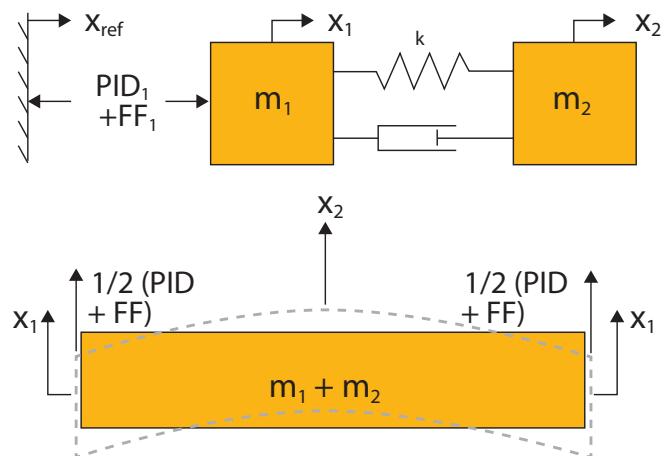


DEFINING REQUIREMENTS

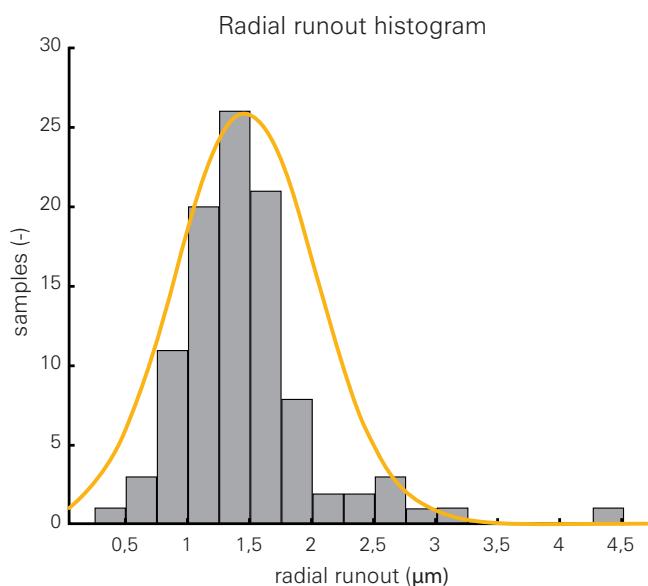
Whether the application involves semiconductor wafer inspection, lithography, electron microscopy or medical diagnostic equipment, a high-performance motion system is often essential. PM understands that each system requires a tailored motion solution to achieve optimal results. PM welcomes the opportunity to collaborate and assist in defining detailed requirements to ensure the best possible system integration. Please contact PM's technical sales team to explore available options and discuss your specific requirements.

CONCEPTUAL DESIGN

Once the requirements are clearly defined and agreed upon, PM's engineers begin investigating your specific challenges during the conceptual design phase. This process helps create a system architecture tailored to your needs.



During this phase, PM leverages historical production data accumulated over more than 55 years. Whether it concerns the runout of a rotary bearing, the straightness of motion in a linear bearing, dynamic characteristics or stiffness behaviour, this extensive knowledge base enables optimal component selection for each motion system. Thanks to fully integrated in-house design and production capabilities, PM can develop fully customised products that ensure maximum system performance and long-term reliability.





ENGINEERED MOTION SYSTEMS EXPERTISE

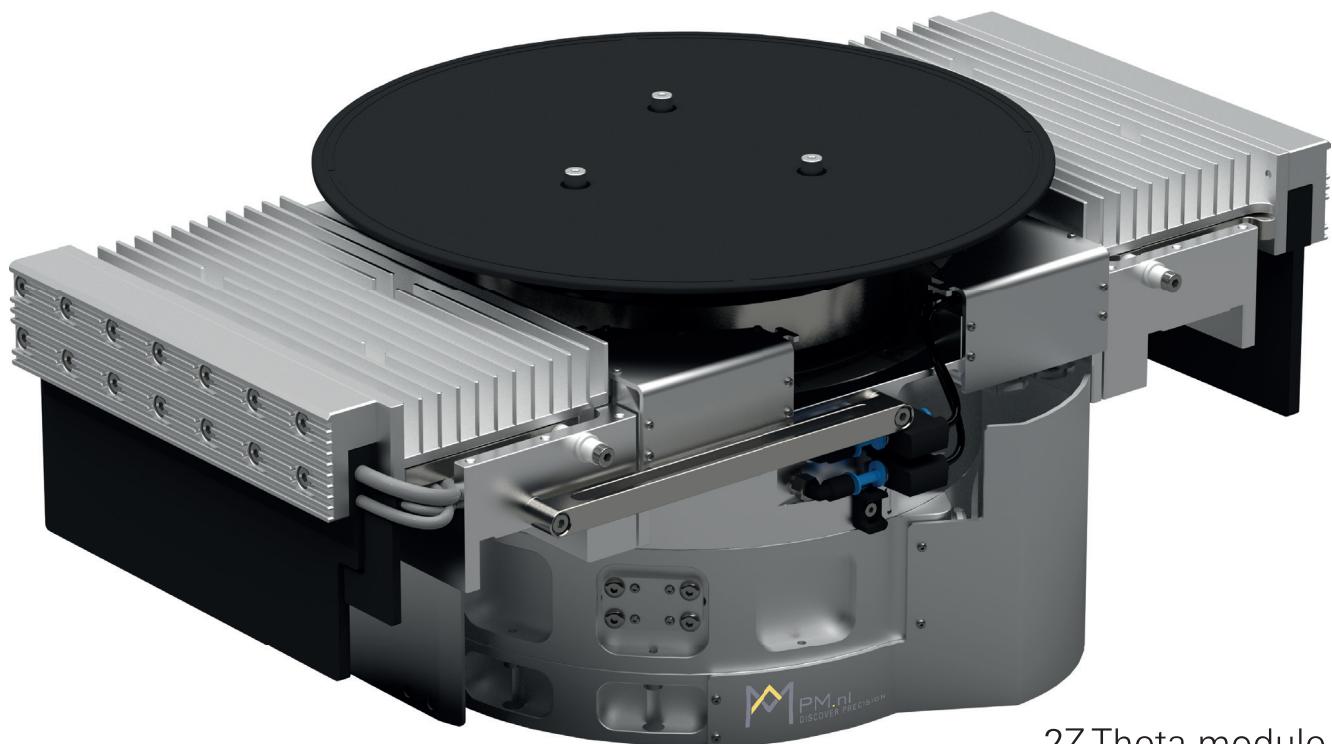


XY2Z-Theta system for wafer inspection with high throughput

ENGINEERED-TO-SPEC MOTION SYSTEM - FROM FIRST IDEA TO DELIVERY

From the initial stages of a custom-engineered motion system project, PM assigns a dedicated project manager and lead engineer, both with extensive experience. They serve as the main points of contact and ensure that all technical and functional requirements are clearly understood. Thanks to PM's flat organisation and short communication lines, decisions are made quickly and effectively. Regular meetings are held to keep the customer informed of progress throughout the project.

- 1. Definition of requirements:** The first step is to define the system requirements. These are formally documented to ensure mutual agreement. PM prepares documentation that outlines the application, project requirements and deliverables.
- 2. Feasibility and concept development:** The defined requirements are translated into a feasibility document, resulting in a conceptual design.

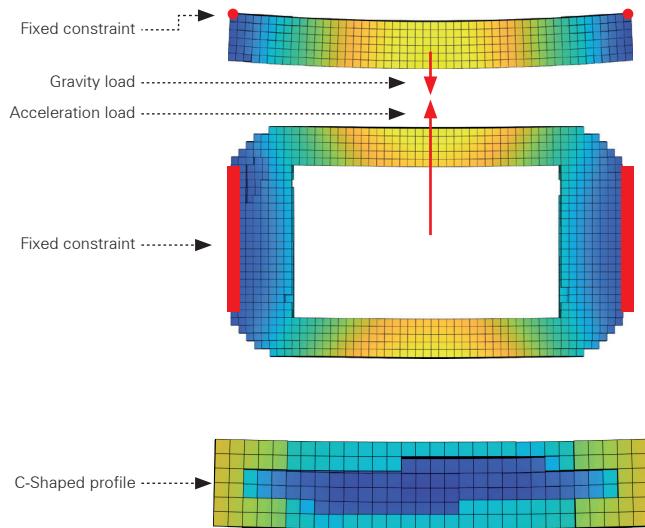


2Z-Theta module

- 3. Proposal phase:** A combined technical and commercial proposal is submitted for customer evaluation.
- 4. Detailed design:** Upon customer approval, PM proceeds with the detailed design phase, following the steps outlined in this brochure. This includes the creation of complete drawings, inspection protocols and assembly instructions.
- 5. Production and assembly:** Following final design approval, PM initiates production and system assembly in-house.
- 6. Testing and verification:** All specified tests are conducted to confirm compliance with the agreed project requirements.
- 7. Repeat orders and change management:** PM finalises all design documentation and manages engineering change requests (ECR) from manufacturing and assembly. This ensures smooth handling of repeat orders in close cooperation with the customer.

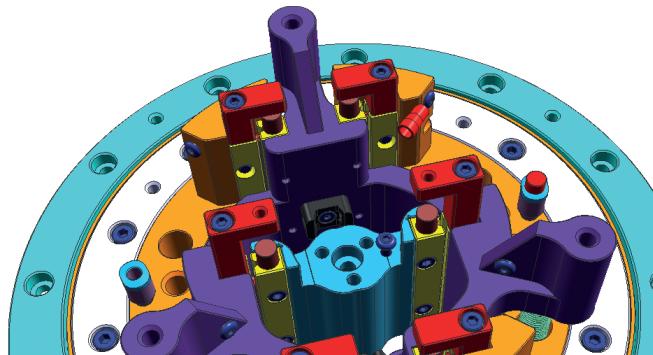


TOWARDS A DETAILED DESIGN



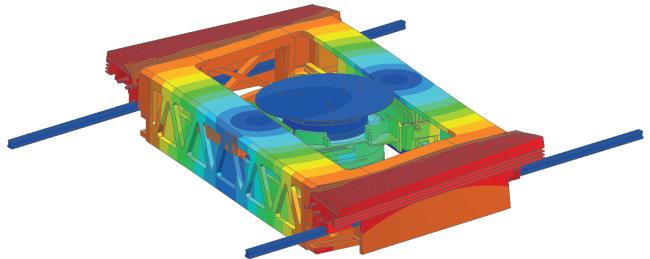
In preparation for the detailed design phase of a motion system, PM utilises various in-house developed tools. The example shown above illustrates how the gantry of a stage is initially shaped using topology optimisation software. This software enables maximisation of the stiffness-to-mass ratio while maintaining manufacturability. Based on this optimisation, the system can determine the most suitable design direction to pursue in the subsequent development stages.

DETAILED DESIGN



Once key design decisions have been made regarding the system architecture, component selection and initial design of structural parts, the design will be fully detailed. An efficient PLM database tracks the developed parts and ensures that no data is lost or unintentionally modified during the design process.

FINITE ELEMENT ANALYSES EXPERTISE



During the detailed design phase, analyses are performed continuously to ensure that requirements are met as the design evolves. PM has expertise in various fields of Finite Element Analysis (FEA), including structural, dynamic, thermal and CFD analyses. All analyses are carried out in-house and directly within the CAD environment, ensuring seamless integration and eliminating the risk of data loss or delays. In addition, PM performs control simulations based on either measured or simulated data, providing a reliable prediction of final system performance.

PRODUCTION AND ASSEMBLY



Once the detailed design phase is completed, the production phase begins. All processes, from precision machining to system assembly, are carried out entirely in-house to ensure the highest possible quality standards. Following assembly, the motion system is qualified to confirm compliance with all specified requirements. To support this, PM's engineering team works with a wide range of tools, including laser interferometers, modal analysis equipment and motion controllers.



EXPERTISE IN ENGINEERED-TO-SPEC MOTION SOLUTIONS

APPLICATION EXAMPLES

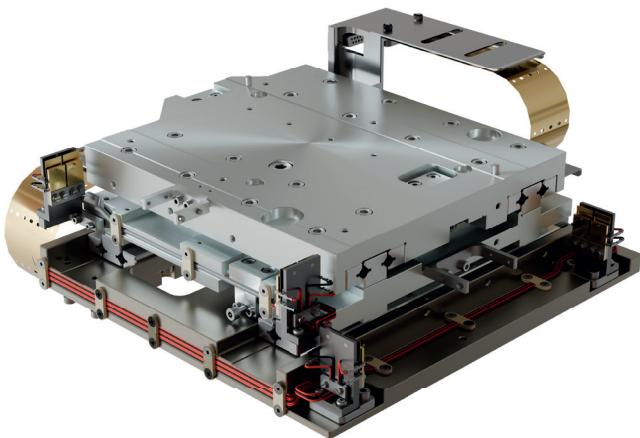
PM is a high-end bearing and mechatronic system supplier, offering full vertical integration from co-engineering to production, assembly and qualification, all performed in-house. With decades of experience in high-precision motion control, PM supports a wide range of applications through the design and realisation of ultra-precise linear and rotary bearings, as well as complex mechatronic subsystems and modules.

PM's application expertise spans the following fields:

- Semiconductor – manufacturing, metrology and inspection
- Life science – electron microscopy (TEM, SEM), micromanipulation, spectrometry, live-cell imaging
- Industrial – micro-assembly, quality inspection, surface inspection
- Photonics – testing and inspection
- Medical – CT scanning, imaging, inspection, robotic surgery, digital pathology
- Analytical – X-ray diffractometers, X-ray microscopes
- Biotechnology – sequencing, microarray scanners, 3D printers

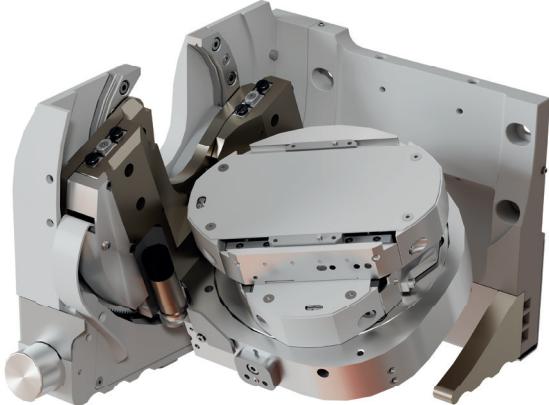
The examples on this page reflect selected customer projects where tailored motion systems were developed to meet specific and demanding requirements.

XY(Z) FOR WAFER LITHOGRAPHY



This XY-positioning stage is designed for 6-inch and 8-inch electron beam lithography applications within the semiconductor industry. The stage is ultra-high vacuum compatible up to 10^{-9} Torr. The delivery includes integrated cable management, motors and switches. To ensure smooth and repeatable motion with zero backlash, the stage is equipped with anti-cage creep crossed roller bearings, offering high stiffness and precision under demanding conditions.

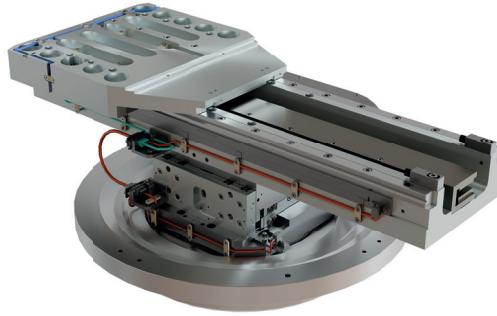
5-AXIS SYSTEM FOR X-RAY DIFFRACTOMETERS



This 5-axis stage assembly is designed for X-ray diffraction applications. The compact design integrates motors, gearboxes and drives within a minimal footprint. A custom-designed ring slide hold the Z, Theta and XY-axes and provides 270 degrees of rotary motion. The XY-stage is mounted on a flat mounted table bearing (type FMB) which can move in Z direction.

The system achieves an overall repeatability of less than 3 microns at tool point. It incorporates backlash-free precision crossed roller linear bearings and mixed drive technologies, including ball screws and worm gear transmissions.

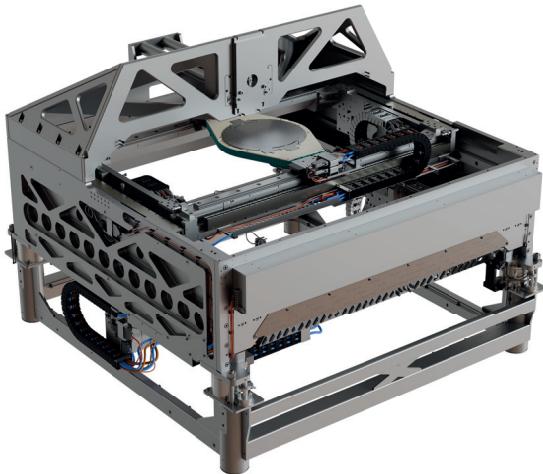
XZ-THETA WAFER HANDLER



This 3-axis system is developed for wafer handling in ultra-high vacuum environments up to 10^{-7} Torr. The Theta axis provides 360 degrees of rotary motion and features our flat mounted table bearing (type FMB), with wobble error below 3 microns. The Z-lift axis is mounted on the Theta axis and uses precision crossed roller linear bearings for smooth, repeatable vertical movement. The long travel X-axis is mounted on top and guided by crossed roller linear bearings with low profile recirculating units with balls (type UK). The system is delivered complete with motors, encoders, switches and cables.

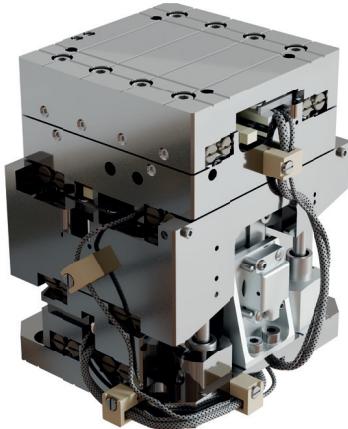


5-AXIS MOTION SYSTEM



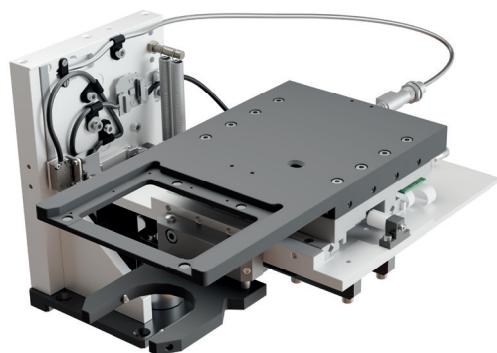
For next generation X-ray metrology, this motion system is developed to deliver high throughput. The X- and Y-axes include long stroke rails (type DS) combined with adjustable ball recirculating units (type UK), providing low friction, smooth movement and zero backlash. The motion system is equipped with vibration isolation units. Non-contact linear motors are integrated to enable fast, precise XY scanning. The Z-axis is guided by precision crossed roller linear bearings (type RSD), ensuring ultra-smooth and accurate vertical motion. Assembly and testing are performed in a cleanroom classified as ISO class 7.

XYZ-STAGE FOR X-RAY MICROSCOPY



For a high resolution X-ray microscopy application, this XYZ-stage is developed for operating in ultra-high vacuum environments down to 10^{-7} Torr. The compact positioning system has a footprint of 70 x 70 mm. Piezo motors and encoders are integrated into the design.

XYZ-STAGE FOR DIGITAL PATHOLOGY



This XYZ-stage is designed for high-precision digital pathology applications, offering sub-micron repeatability. The Z-axis is driven by voice coil actuators, while the X- and Y-axes are powered by linear shaft motors. The stage combines a compact, lightweight and flat design with accurate and fast scanning of tissue samples in digital slide desktop scanners. The system is developed with in-house manufacturing and motion control expertise and can be tailored to next generation pathology workflows. Whether the focus is high throughput imaging, AI-based analysis or next generation pathology workflows, PM precision positioning solutions enable reliable and repeatable results.

XYZ-STAGE FOR ELECTRON MICROSCOPY



This compact open frame XYZ-positioning stage is developed for high precision motion in electron microscopy applications under vacuum conditions. With a stroke range of 50 x 50 x 0.3 mm, the stage meets flatness and straightness specifications below 1 micron, ensuring exceptional stability and accuracy. The system is equipped with stainless steel crossed roller bearings (type RSDE) featuring anti-cage creep technology (ACC), enabling smooth, backlash-free motion during long-term operation. Piezo-driven actuators provide ultra-precise positioning, while integrated optical linear encoders deliver high-resolution feedback for optimal control. This custom vacuum compatible solution is engineered for applications where sub-micron accuracy is critical.

EXPERTISE WORLDWIDE AVAILABLE

PM provides long-term support through a global network of qualified partners offering sales assistance, technical advice and local service.



- Headquarter Dedemsvaart, the Netherlands
- Sales partners

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