

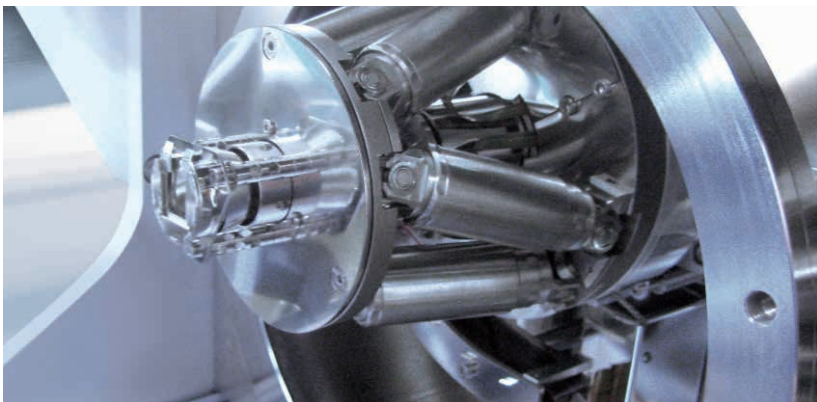
Positioning in Vacuum

HIGH-PRECISION SOLUTIONS TO 10^{-10} HPA

Applications in Scientific Research and Industrial Production

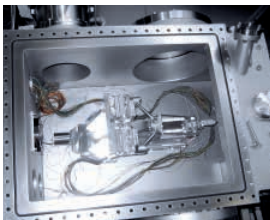
POSITIONING SAMPLES ON 6 AXES

In addition to positioning, fine alignment of the surface is often necessary. Parallel-kinematic solutions allow individual modification of the tip/tilt angle over a large area, without the need to move the sample away from the target position. Brushless DC motors for up to 10^{-6} hPa were used in the drivetrain.



The hexapod with 100 mm platform diameter enables relatively long travel ranges in minimal installation space (image: SURFACE)

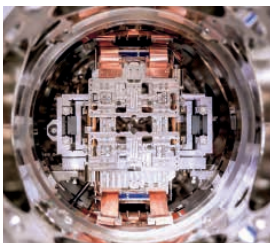
3-D ALIGNMENT OF THE X-RAY MICROSCOPE OPTICS



This 7-axes system positions optical elements in a high-vacuum environment of 10^{-7} hPa with a precision of less than 100 nm and 10 μ rad. A stable position, excellent repeatability, and high stiffness are essential requirements.

6-axes SpaceFAB on a linear stage in the vacuum chamber (image: BESSY, HZB)

ALIGNING THE X-RAY CAMERA IN UHV



Two platforms position pnCCD cameras that are sensitive to X-rays on this flat linear stage precisely in relation to each other over a travel range of 50 mm and in a defined alignment to the X-rays. The stainless steel base body, which is combined with special stepper motors and an absolute-measuring, high-resolution linear encoder, is adapted to the environment of 10^{-9} hPa.

Image: SLAC National Accelerator Laboratory

OPTIMIZED THROUGH-PUT IN PRODUCTION SYSTEMS

Low vibration, fast and precise positioning

Production under vacuum conditions is increasing in importance. This is already firmly established in semiconductor production, but new technologies such as those used for coating or the manufacture of sensors would also benefit. Here, the reliability of the various components is particularly important, because interruptions due to possible contamination can be very costly. Particularly with high loads, it is important to avoid residual oscillation in order to keep the throughput consistently high.



Automated sandwich pick-and-place machine for large area films in HV to 10^{-6} hPa. The parallel-kinematic SpaceFAB positions on 6 axes and is distinguished by its low profile

Motion and Positioning in Vacuum Conditions to 10^{-10} hPa

Our expertise: Drive technology, application-specific adaption, complete solutions

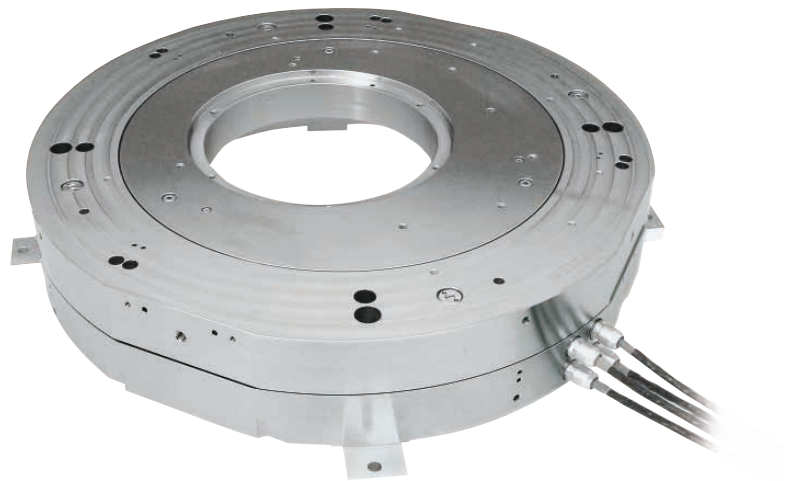
The PI Group stands for continuous advance in precision positioning, which is driven by a passion for technology. PI draws on a wide range of drive, sensor or guide components. We therefore ensure a solution that is not restricted to specific technological concepts.

In addition to the broad technological range, a high degree of vertical production allows complete control of all processes. The fractal production model guarantees an efficient production process for individual production runs, small volumes or OEM products in high quantities.

Flexible selection of the drive

Various different drive technologies are available to PI for the vacuum applications: This includes the piezo actuator, which can also work in strong magnetic fields and a cryogenic environment, piezo systems with travel ranges of less than 1.5 mm and subnanometer precision, piezo motors in various different designs with respect to force, dynamics, and travel range as well as classical motorization with specially designed DC or stepper motors, that allow greater travel ranges.

Operating positioning solutions in a vacuum follows clearly-defined constraints. This initially applies to the normally limited installation space. Contamination of the vacuum chamber with particles from abrasion or outgassing must be prevented, but also excessive heat input.



Piezomotor drives also work very reliably in UHV environments, here on 6 axes

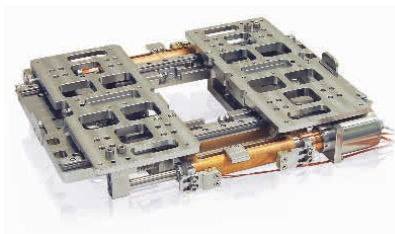
This means that selection of the optimum drive technology for the respective application and the mechanical design must be matched exactly to the required load capacity and velocity as well as the intended operating and planned duty cycles.

Always the best solution

Whether it is a positioning stage that is available quickly from the large portfolio or an individually adapted solution: Our very experienced specialists will give you sound advice. In addition to the mechanical positioning system, the complete solution from PI also includes the controller and the software – from one single source!



UHV linear stage from the Q-Motion series with integrated position-measuring system

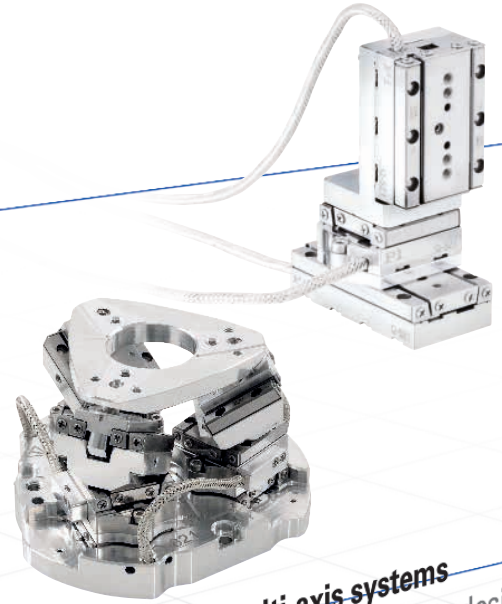
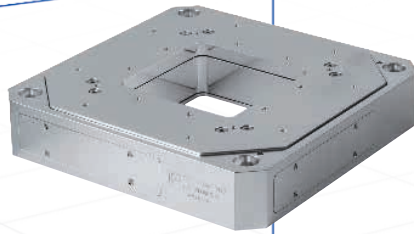


Careful selection of the components even allows complex solutions with electromagnetic motors

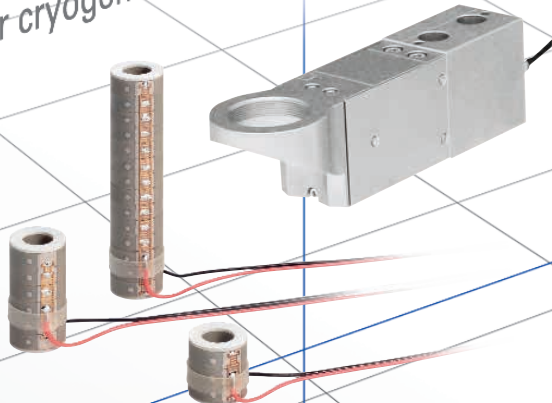
Product Overview

NUMBER AND TYPE OF AXES

Parallel-kinematic piezo scanning stages
Up to six axes. Capacitive, direct-measuring sensors for position stability and subnanometer resolution. Optional nonmagnetic versions



Piezo direct drives
For dynamic applications with high forces. Displacements to 1.5 mm. Also for nonmagnetic or cryogenic environment



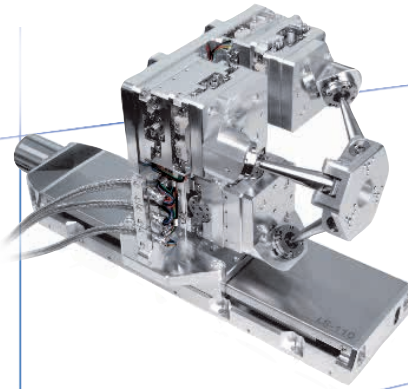
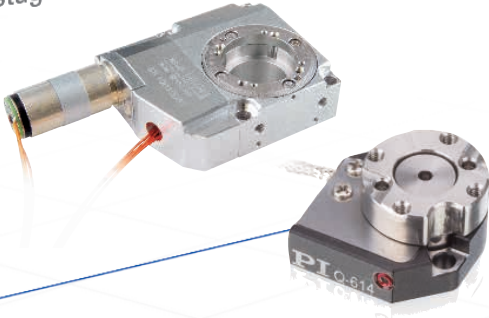
Compact multi-axis systems
Stacked or parallel-kinematic design. Piezomotor drives. Optional nonmagnetic versions

Linear actuator
with piezomotor for high resolution and drift-free long-term positioning



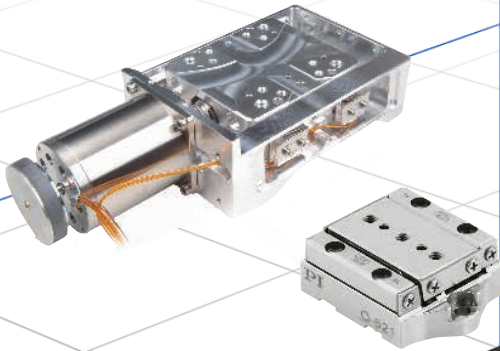
Rotation stages

Scalable, from 14 mm platform diameter up to the high-load-rotation stage with >100 mm aperture



Custom development and system design
Virtually unlimited number of axes specified by the application. Control and user software included

Linear stages
Q-Motion miniature linear slides and stepper motor stages for long travel ranges to several 100 mm

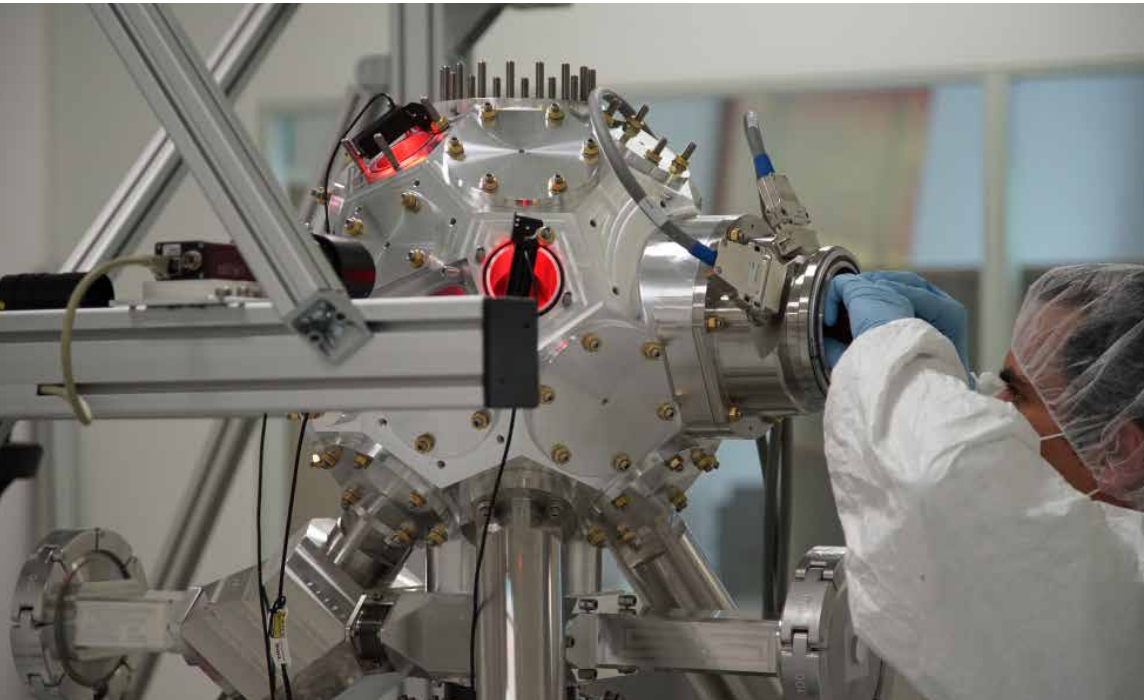


TRAVEL RANGE

Specifications

- Standard solutions to 10^{-9} hPa, customization to 10^{-10} hPa on request
- Position resolution to less than 1 nm with piezo direct drives, less than 1 μ m with motorized stages
- Travel range of a few 10 μ m up to several 100 mm, optionally even more
- Load capacity optionally up to several 100 kg

Technology and Know-how



Assembling and testing takes place according to strict regulations under defined cleanroom conditions or in flow boxes. The image shows a vacuum sample chamber with flanges for a number of X-ray spectrometers that allow measurement over a large acceptance angle

Design principles for vacuum-compatible positioning systems

The selection of suitable materials is of particular importance. The material may not outgas and must be resistant to heat in order to overcome the bakeout temperatures necessary for higher vacuum classes. The required precision and the high position resolution, and flatness must be maintained.

Particular attention must be paid to the surfaces and the surface treatment. The top priority is to keep the surface as small as possible. Covers that protect against contamination under normal atmospheric pressure can often just be ignored. Black anodized aluminum is still permissible up to high vacuum levels of 10^{-6} hPa but under that, bare surfaces are indispensable.

In addition, it is important to ensure that air pockets are avoided. In a vacuum, they act like virtual leaks and lead to continuous contamination of the vacuum.

Handling, assembling, and testing

The conditions and handling regulations for vacuum positioning systems are just as important as the design principles. All parts must be cleaned first, dried, and vacuum grease must be applied to the guides and bearings. Cleanrooms are available for assembling larger parts.

Suitable packaging and the corresponding instructions for the recipient are part of shipping.



Accessories such as feed-throughs can be individually adapted



View in the vacuum chamber. Here, a multi-axis design awaits start-up and outgassing measurement

Quality control

For start-up, vacuum chambers are available in several sizes. In addition to function checks, interferometric measuring of position accuracy under real operating conditions is also possible.

Vacuum compatibility can be tested up to a level of 10^{-10} hPa using the existing equipment. A mass spectrometer allows testing for residual gas in the chamber. This means that sources of contamination can be eliminated and virtual leaks detected.

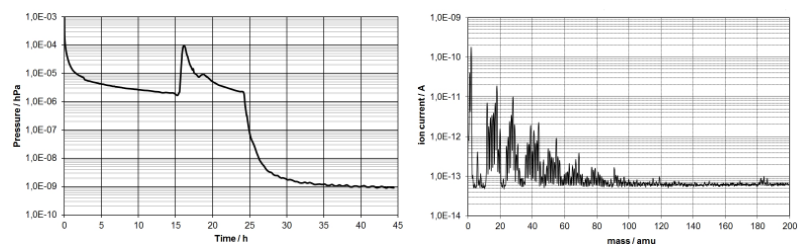


At PI, several vacuum chambers are available in various different sizes

The various vacuum classes

Vacuum class	Abbreviation	Pressure range
Low vacuum	FV	<1 hPa to 10^{-3} hPa
High vacuum	HV	< 10^{-3} hPa to 10^{-7} hPa
Ultrahigh vacuum	UHV	< 10^{-7} hPa to 10^{-12} hPa
Extreme ultrahigh	XHV	< 10^{-12} hPa

Typical logs of pump-out to UHV level and residual gas scan





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