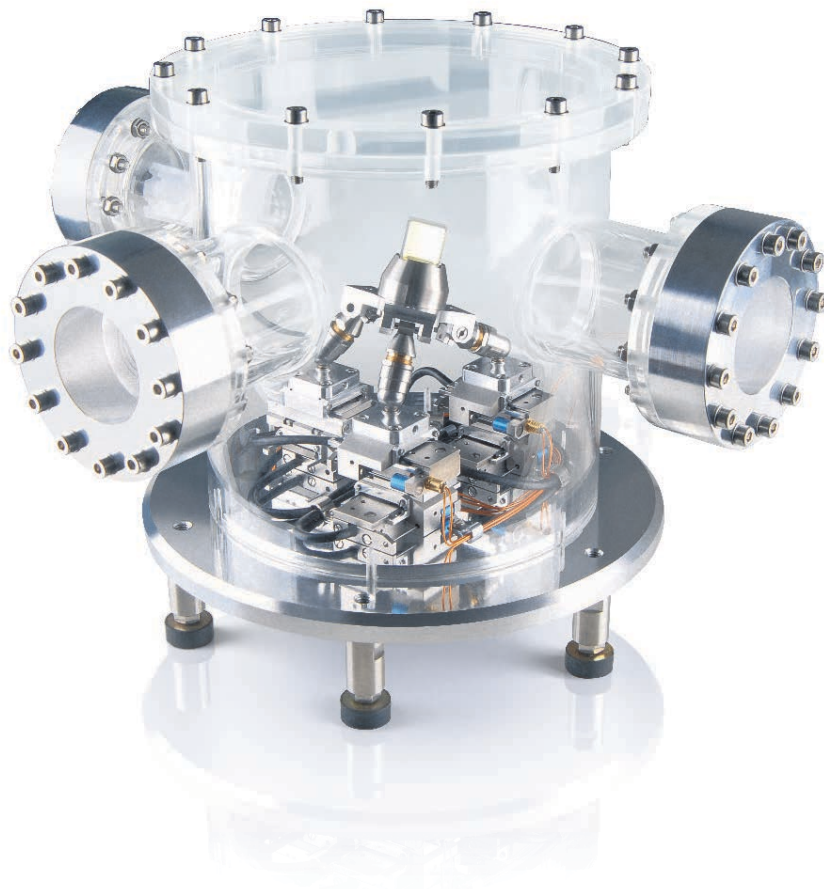
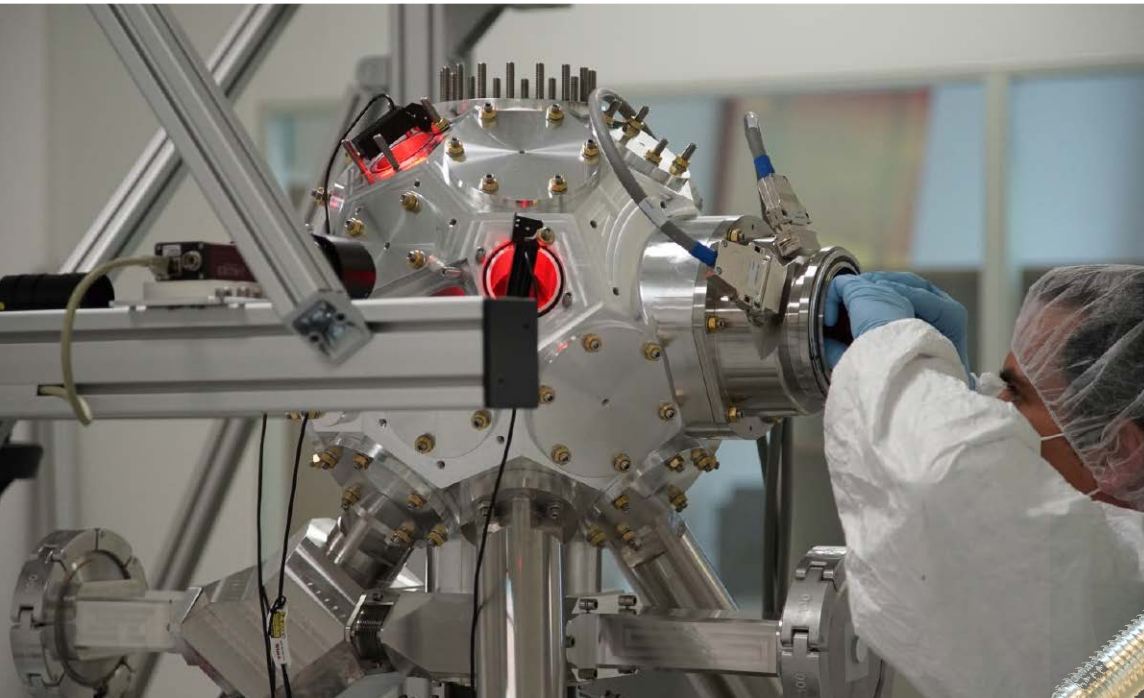


Precision Motion and Positioning Solutions for High Vacuum and UHV



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

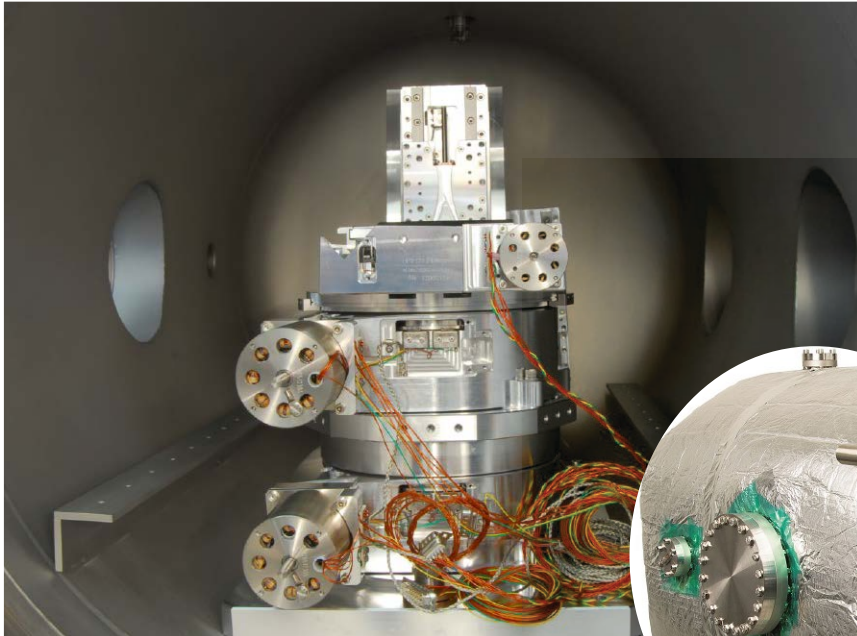
The conditions and handling regulations for vacuum positioning systems are just as important as the design principles. All parts must be cleaned first, dried, and vacuum grease must be applied to the guides and bearings. Cleanrooms are available for assembling larger parts.

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

Silver-coated vacuum screws with ventilation holes minimize outgassing and risk of virtual leaks



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

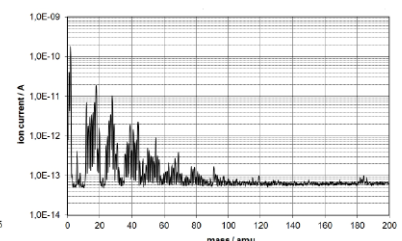
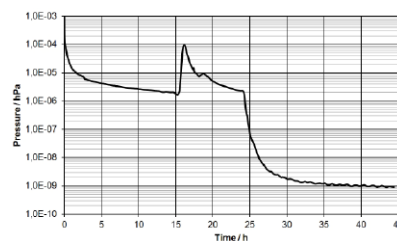
For start-up, vacuum chambers are available in several sizes. In addition to function checks, interferometric measuring of position accuracy under real operating conditions is also possible.

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

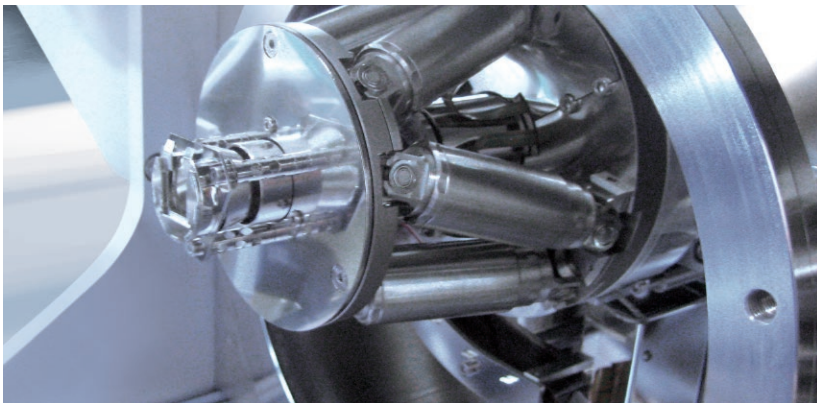


Typical logs of a pump-out phase with bakeout phase to UHV level (left) and a residual gas scan (right)

Applications in Scientific Research and Industrial Production

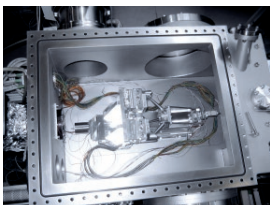
POSITIONING SAMPLES ON 6 AXES

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)

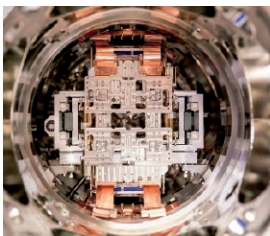
3-D ALIGNMENT OF THE X-RAY MICROSCOPE OPTICS



This 7-axis 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-axis SpaceFAB on a linear stage in the vacuum chamber (image: BESSY, HZB)

ALIGNING THE X-RAY CAMERA IN UHV



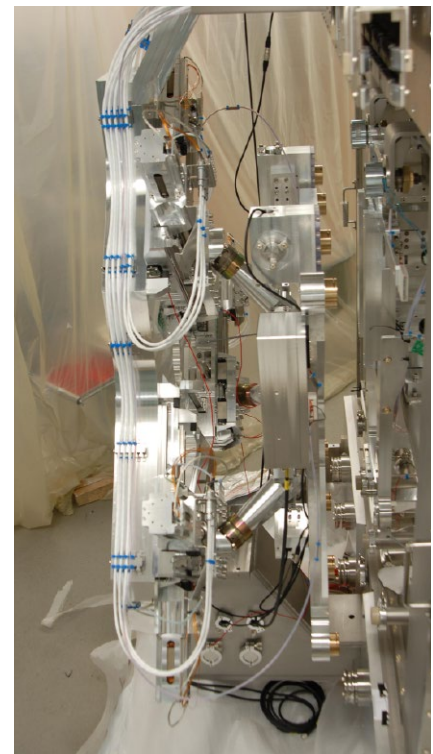
Two platforms position pnCCD cameras that are sensitive to X-rays on this flat linear stage precisely in relation to each other over a travel range of 50 mm and in a defined alignment to the X-rays. The stainless steel base body, which is combined with special stepper motors and an absolute-measuring,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

View of the vacuum chamber with the integrated double linear stage (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

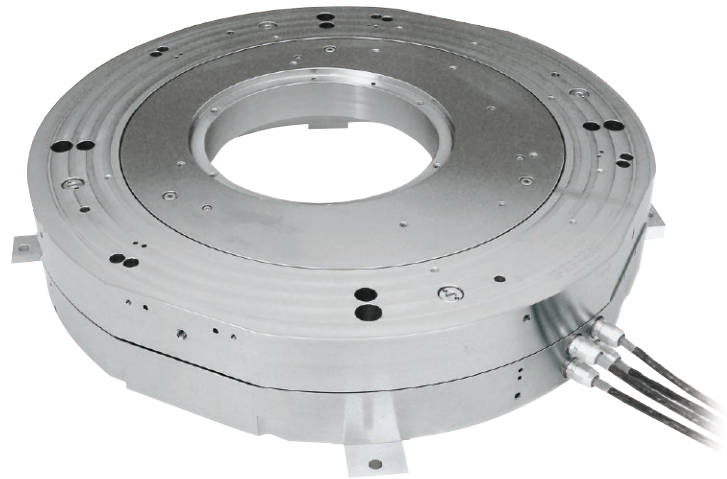
The PI Group stands for continuous advance in precision positioning, which is driven by a passion for technology. PI draws on a wide range of drive, sensor or guide components. We therefore ensure a solution that is not restricted to specific technological concepts.

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

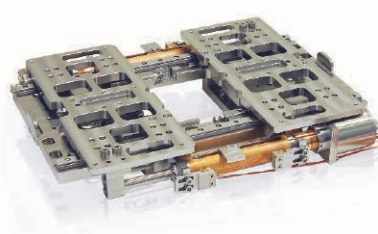
This means that selection of the optimum drive technology for the respective application and the mechanical design must be matched exactly to the required load capacity and velocity as well as the intended operating and planned duty cycles.

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



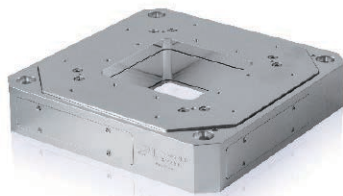
Careful selection of the components even allows complex solutions with electromagnetic motors

Product Overview

Number and type of axes

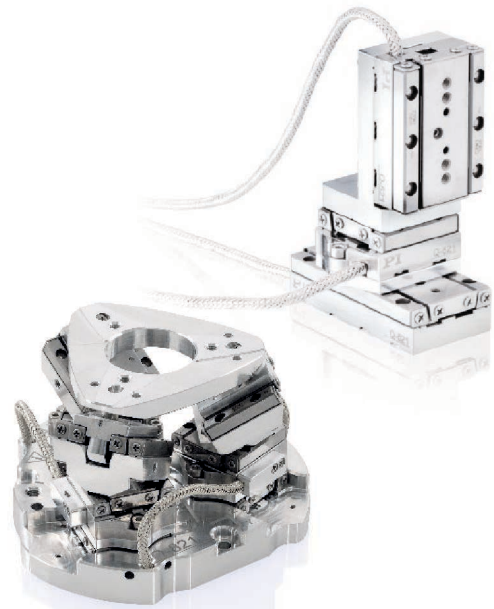
PARALLEL-KINEMATIC PIEZO SCANNING STAGES

Parallel-kinematic piezo scanning stages with up to six axes with integrated capacitive, direct-measuring sensors in various different versions, optional nonmagnetic versions. Up to kHz dynamics, subnanometer resolution



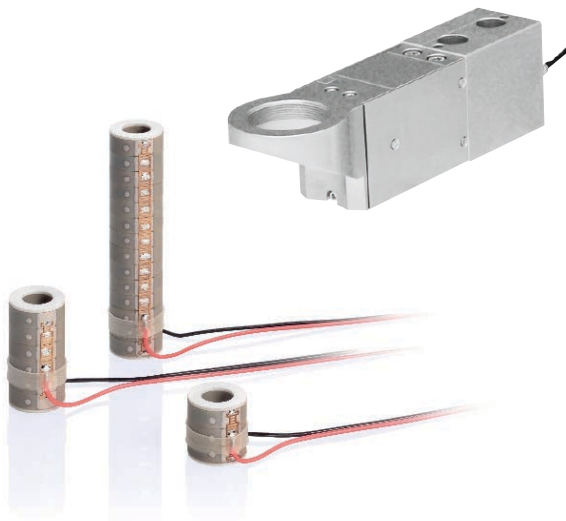
PIEZOMOTOR DRIVES

Piezomotor drives allow particularly compact positioning stages and therefore also multi-axis systems, whether stacked or as space-saving parallel-kinematic hexapod or SpaceFAB design



PIEZO DIRECT DRIVES

are suitable for dynamic applications even with high forces and offer displacements to 1.5 mm with minimal space requirement. Nonmagnetic versions are available as an option and also allow motion in a cryogenic environment



LINEAR ACTUATOR

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



Travel range

ROTATION STAGES

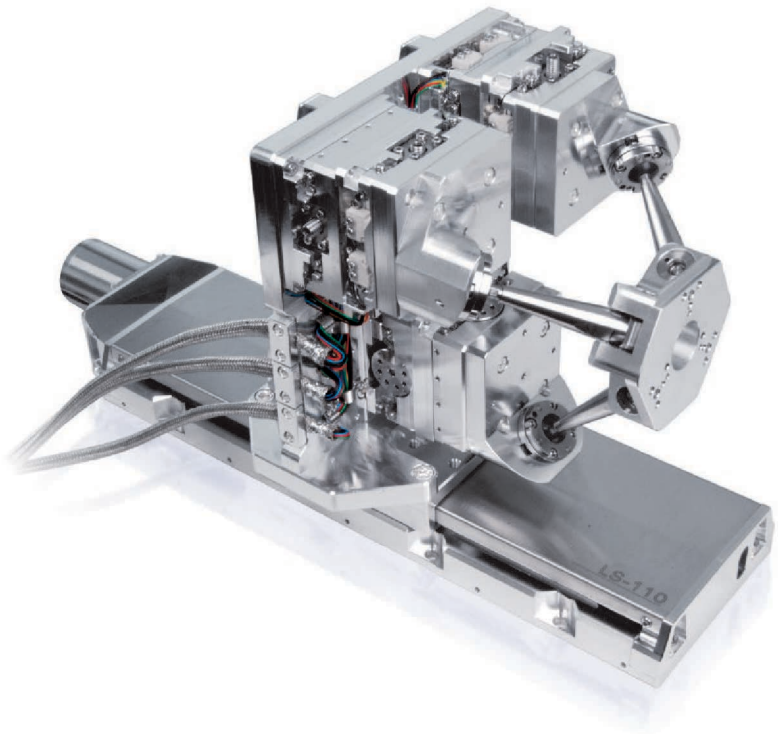
Rotational motion in vacuum due to scalable drives, from the piezomotor with and without position control from 14 mm platform diameter up to the high-load-rotation stage with >100 mm aperture.



CUSTOM DEVELOPMENT AND SYSTEM CONSTRUCTION

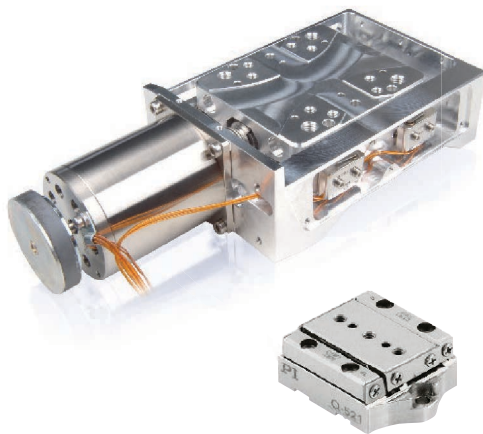
Custom development and system construction is taken seriously at PI, particularly for complex surroundings.

The number of axes is virtually unlimited and is specified by the application. Control and user software included



LINEAR STAGES

Ideal in UHV environments: Miniature linear stages from the Q-Motion series and stepper motor-driven linear stages for longer travel ranges to several 100 mm



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 $1 \mu\text{m}$ with motorized stages
- Travel range of a few $10 \mu\text{m}$ up to several 100 mm, optionally even more
- Load capacity optionally up to several 100 kg

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Well-Positioned All Over the World

The PI Group is present in all key technology regions world-wide. Its local representations around the globe are more than just sales agencies. Customers benefit from this in many ways:

- Service facilities for diagnosis and repair as well as metrology equipment for tests, system calibration and quality assurance
- R&D departments, which are able to react promptly to the demands of the local markets and ensure a direct dialog with the customers
- Sample and prototype construction – in close contact with development departments and customers
- Sales and application engineers – experts for the entire product portfolio of the PI Group and your contact for customized developments – from the initial consultation to the delivery
- Market and business development experts who listen to what customers in specific market segments want and enable the PI Group to develop products that fulfill these requirements.

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