



Motion | Positioning

PRODUCT OVERVIEW

The PI Group



No other company in the world offers a broader and deeper portfolio of precision motion technologies than the PI Group. Continuous growth through the development of novel products and technologies is one of the main characteristics of the PI Group.

Novel drive concepts, products and system solutions have led to a continuous growth in market shares and a healthy company development in the past years. With more than 800 highly qualified employees all over the world, research and manufacturing centers on three continents and subsidiaries in 13 countries, the PI Group is in a position to fulfill almost any requirement with regard to innovative precision motion technology.

Air Bearing Stages

Linear, XY, Rotary, Miniature to High Load



Motorized Linear Stages

- Travel to 750mm, Load to 50kg
- Velocity to 2m/s
- Acceleration to 2G's
- Straightness/Flatness to 0.25 μ m



Planar XY Stages

- Travels to 500mm x1000mm
- Dynamic Yaw Control & Error Compensation
- Velocity to 1m/s, Acceleration to 1G



Motorized Rotary Stages

- Diameter to 300mm
- Load to 500kg
- Optional Slipping Assembly
- Clear Apertures Available



Spindles / Machining

- Zero to 80,000rpm
- High Radial Stiffness
- High Resolution Encoders
- Vacuum Feedthrough Option



Linear & Rotary Bearings

- Load to 750kg
- Runout < 0.1 μ m
- Wobble to 0.5 μ rad
- Straightness/Flatness < 0.5 μ m/25mm

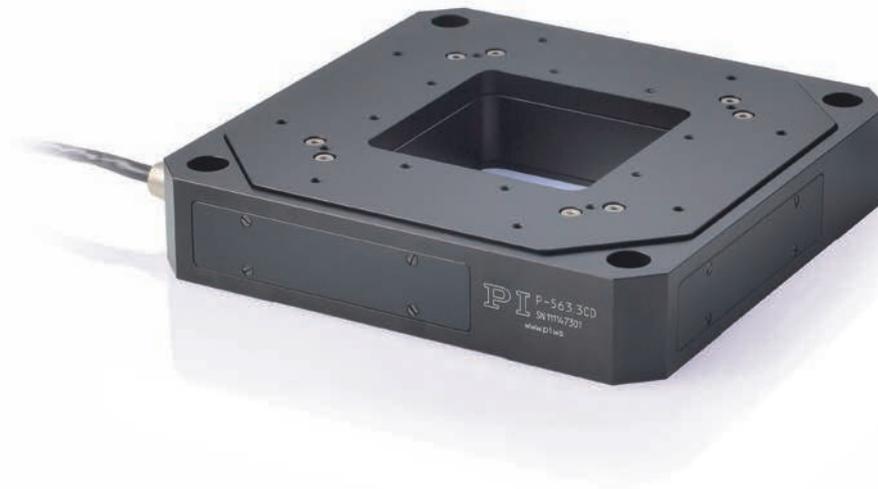


Spherical Air Bearings

- For Planarization and Assembly
- For Satellite Attitude Control Testing
- Load to 635kg

Piezo Scanners for Nano-Precision Positioning

In One to Six Axes



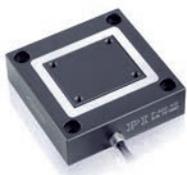
Precision Positioning Stages for up to 6 Axes

- Parallel kinematics with capacitive sensors
- Optimum linearity
- Travel ranges to 800 μm



Cost-Efficient Multi-Axis Systems

- Modular design for up to three axes
- SGS position sensors



Single-Axis Piezo Scanning Stages

- Excellent precision
- Friction- and backlash-free flexure guidings
- High dynamics, travel ranges to >1 mm



Fast Tip/Tilt Mirrors

- Two orthogonal, parallel-kinematic tip/tilt axes with common pivot point
- Frequencies to >1 kHz



PicoCube® XYZ Piezo Scanners for AFM

- Picometer resolution
- Nonmagnetic and UHV versions available

Highly reliable PICMA® piezo actuators, flexure guidings and capacitive sensors are the basis of piezo scanning stages featuring highest travel accuracy and linearity.

Sample and Objective Scanners

Fast and Precise Positioning in Microscopy



PIFOC® Objective Scanners with Millisecond Settling Time

- Scans and positions objectives with sub-nm resolution
- Travel ranges to 2 mm



Precision XY Stages

- For Nikon, Zeiss, Leica and Olympus microscopes
- Fast XY scans, stable positioning



Z Sample Positioning for Fast Focus Control and Imaging

- Stable positioning
- Fast response times



Positioning Revolving Nosepieces of Microscopes

- Minimum objective offset and excellent focus stability



High-Precision Multi-Axis Sample Positioning with Plnano®

- Low height for installation in microscope
- Recessed sample holders

The systems for microscopy include controller and software. Configuration and parameter setting is done via software. Supports third-party software packages, such as MetaMorph, μ Manager, MATLAB or ScanImage. State-of-the-art interfaces: USB, TCP/IP, PIO, serial real-time interfaces.

Miniature Linear Stages

Piezo, Servo, Stepper Motors



High-Resolution Precision Stages

- With piezomotor and direct position measurement
- 0.5 nm resolution
- Nonmagnetic drive



Miniature Stages, Only 24 mm Wide

- 5 N feed force
- With piezomotor and direct position measurement
- Vacuum versions to UHV available



Highly Dynamic PLine® Stages

- To 250 mm/s
- With piezomotor and direct position measurement
- Nonmagnetic drive



Open-Loop Miniature Stages

- Only 22 mm wide
- Vacuum versions to UHV available
- With piezomotor



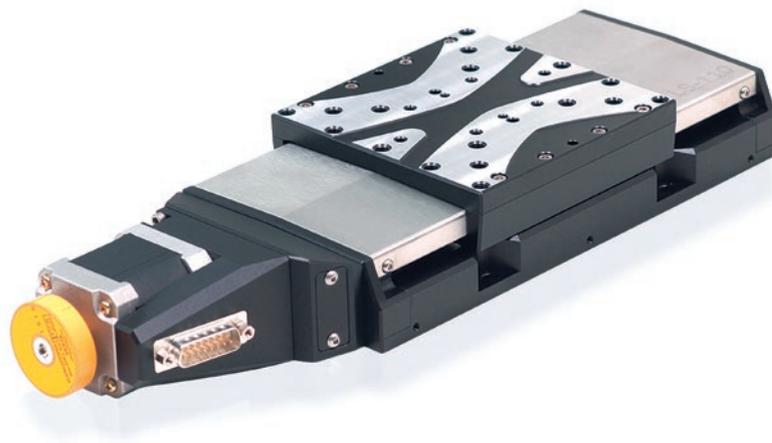
Precision Micropositioning Stages with Electric Motors

- Compact XY und XYZ configurations
- With DC or stepper motors

Piezomotors are direct drives with different force and velocity development. They transfer the characteristics of piezoactuators to larger travel ranges, e.g for nanometer-precision positioning systems.

Precision Linear Stages

Travel to 1000 mm



Dynamic with Direct Drive

- Linear motor
- High travel accuracy
- High-resolution position measurement



Z Stages

- Different load classes
- Integrated limit switches



High-Precision Positioning Stages

- For loads to 1000 N
- Variable travel ranges
- Large number of motor variants



XY Stages

- Scanning systems for inspection and microscopy tasks
- Large number of motor variants



Cost-Efficient Linear Stages

- Large number of motor variants and different travel ranges



Linear Positioning Stages with Piezomotors

- Precise with direct position measurement
- Self-locking at rest
- Low height

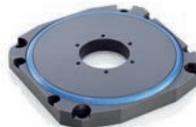
Rotation Stages

From Miniature Size to Ultraprecision



Miniature Rotation Stages

- 14 to 32 mm Ø
- Directly driven with piezomotor
- Self-locking at rest
- Vacuum versions available



Low-Profile Rotation Stages

- Fast step-and-settle on target
- Directly driven with piezomotor
- Self-locking at rest



Fast Miniature Rotation Stages

- >720°/s
- With integrated position sensor
- Directly driven with piezomotor
- Self-locking at rest



Compact Rotation Stages with Electric Motors

- Backlash-compensated drive
- With DC or stepper motors



Ultra-Precise with Air Bearings

- Wobble-free motion without friction effects
- Stable constant velocity also at low velocities



Stable High-Load Rotation Stages

- With clear aperture
- Large number of motor variants



Backlash-Compensated Drive

- With clear aperture
- Large number of motor variants
- Different sizes



Goniometers

- Smooth operation
- 2-axis installation with common pivot point

Parallel Kinematics, Hexapods

6 DOF, Nanometer Resolution



Miniature Hexapod

- Repeatability to 0.1 μm
- Versions for fiber positioning
- Versions as high-dynamics motion Hexapods



Hexapods for Nanometer-Precision Alignment

- PiezoWalk® piezo stepping drives
- UHV-compatible and nonmagnetic



Precision Hexapods

- Repeatability to 0.1 μm
- Vacuum versions available
- Simpler versions available



High-Load Hexapods for 1000 kg Load

- Excellent precision
- Repeatability to 1 μm



Scalable Design for Flexible Solutions

- Fast adaptation of travel ranges and angle ranges through modular construction
- Low total height



Vacuum Versions to UHV

- With stepper or piezomotors



Precision Micro Robots

- With DC, stepper or piezomotors
- Large travel ranges in X and Y



Miniaturized Versions

- Piezomotor drives

Parallel-Kinematic Six-Axis Design

- Compact
- Large travel ranges
- Freely definable pivot point
- Systems incl. digital controller and comprehensive software package
- Position commands in Cartesian coordinates

- Vector algorithms
- Optional SPS/CNC interface, optical inputs, large selection of accessories, such as manual control
- Host software, simulation programs, Windows and Linux DLLs, macro programming

Precision Actuators, Automation Actuators

Stepper, Servo, Piezo, Voice Coil



Compact Precision Actuators

- High-resolution drives
- Backlash-free design
- Vacuum versions available



PiezoMike for Drift-Free Long-Term Positioning

- Stable alignment of opto-mechanical components
- Vacuum versions to UHV available



High-Load Actuators

- Axial force to 400 N
- For industrial automation



PIMag® Magnetic Direct Drive

- High dynamics
- Low wear
- Optional force control



Cost-Efficient Linear Actuators

- With stepper motor
- Nonrotating tip

Compact positioning solutions for limited installation space, for applications such as in testing and inspection systems in industry and research. The non-rotating tip for uniform feed prevents wobble, torque, and wear at the point of contact.

Piezo Actuators & Motors

High Dynamics, Sub-Millisecond Response Time, Picometer Resolution



Flexure-Guided Multilayer Actuators

- Cost-efficient OEM solutions for integration
- Travel ranges to >1 mm



Encapsulated PICMA® Piezo Actuators

- For use in a tough environment



Preloaded Piezo Stack Actuators

- Variable end pieces
- High stiffnesses
- UHV designs



DuraAct Piezo Transducers

- For actuator or sensor applications, structural health monitoring
- Bendable, robust and preloaded through lamination



OEM Piezo Amplifiers and Controllers

- Universal control for static and highly dynamic applications
- Analog und digital interfaces

Preloaded piezo actuators are perfectly suited for highly dynamic applications. A lever amplification with friction-free flexure guidings provides larger travel ranges and guides the motion. Piezo amplifiers and controllers are available in different designs.

Piezo Actuators & Motors

Alternative Drive Concepts: Non-Magnetic Drives and Piezomotors



PIShift Piezo Inertia Drives

- Self-locking at rest
- Forces to 10 N
- Silent and energy-saving



PILine® Ultrasonic Piezomotors

- To 500 mm/s
- Self-locking at rest
- Fast step-and-settle



NEXLINE® High-Load Actuators with Piezomotors

- Feed force to 800 N
- Nanometer resolution
- Optional position measurement



PiezoWalk® Piezo Stepping Drives

- Nanometer precision with a high feed force
- Self-locking at rest



- Piezomotors are nonmagnetic and vacuum-compatible
- Easy integration and affixing of load
- Drive electronics and controllers for all integration levels

Piezo Components

Variable Designs, Optionally with Position Measurement, UHV Versions



PICMA® Multilayer Piezo Actuators

- Low piezo voltage to 120 V
- Travel ranges to 38 μm
- High stiffness



PICMA® Multilayer Bender Actuators

- Bimorph structure for bidirectional displacement to 2 mm
- Low operating voltage to 60 V



Piezoelectric Components

- Ultrasonic transducers in various shapes: Disks, plates, tubes
- High resonant frequencies to 10 MHz



PICA High-Load Stack Actuators

- Travel ranges to 300 μm
- Forces to 78,000 N
- Available with clear aperture



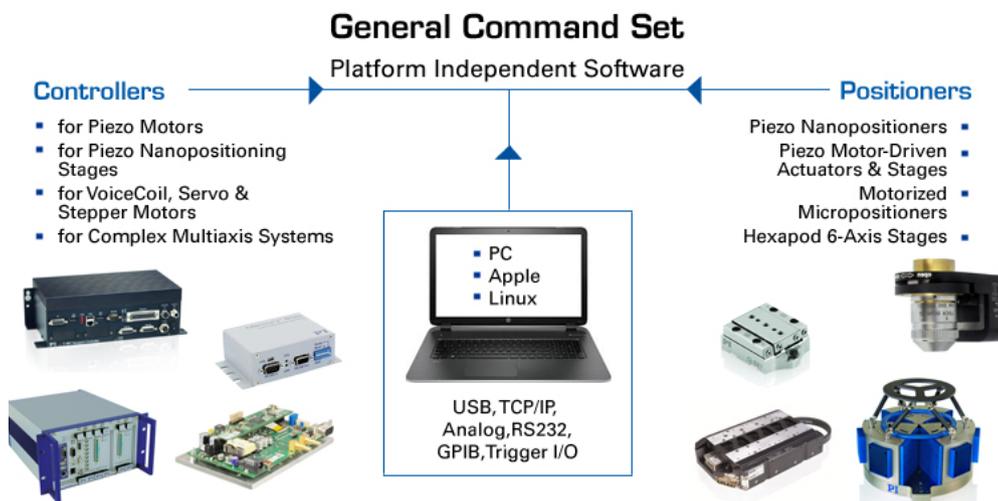
OEM Adaptations, Assembling Technology

- Piezo transducers for ultrasonic applications
- Complete transducer components

The piezoceramic materials can be adapted individually to perfectly fit the later use of the piezo components. Lead-free piezo ceramics are available for the construction of sensor components. Actuators made of piezo crystals provide a hysteresis-free linear displacement.

Control Electronics & Software

From the OEM Amplifier to the Digital Multi-Axis Controller



Precision positioning in the nanometer range and complex drive technologies require a control technology which is matched to the characteristics of the system.

For achieving optimum system properties, PI develops

- Noise-less and highly stable amplifiers,
- Adapted control concepts that improve settling behavior, path accuracy and dynamic behavior,
- Linearization algorithms for electronics, sensors and the mechanical system,

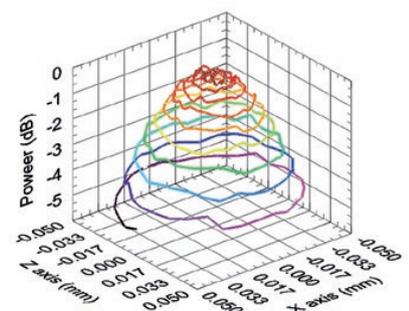
- Digital controllers, that allow system control and change of parameters conveniently via software,
- Digital real-time interfaces and the connection to industrial standard interfaces.



PI adapts the drive electronics always to the application requirements: Laboratory applications, complex multi-axis positioning systems or compact solutions for integration

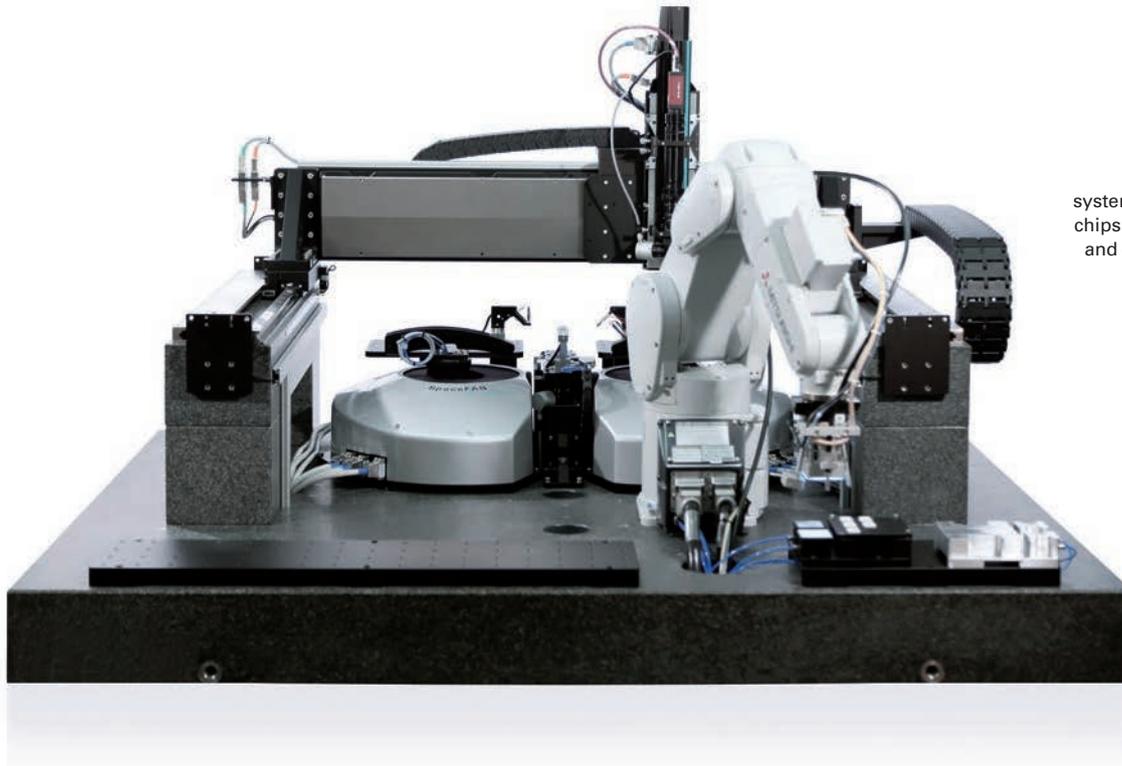
All digital controllers made by PI are accompanied by a comprehensive software package. The PI software provides a range of functions, such as data recorder, wave generator, waveform memory for motion profiles, coordinate transformation, reading out of ID chips in the mechanical system or macro operation.

- Universal command set for all products
- Host software for fast start-up and system optimization
- Tools for adaptation of parameters and system optimization
- Scan algorithms for photonics
- System integration of third-party equipment
- Simulation programs for parallel-kinematic systems
- Supported languages and software environments: C, C++, Python, Visual C++, VisualBasic, Delphi, LabVIEW, MATLAB, μ Manager, EPICS, TANGO, MetaMorph. All programming environments that support the loading of DLLs
- Convenient graphical user interface for displaying all controllers and axes
- Software drivers for D/A boards
- Integration in text-based programming languages



Fine adjustment for fiber array coupling with optical feedback

Motion Control / System Integration



Production and testing system for packaging microchips with integrated optical and electronic components

Frequently, the complete integration of multiple axes of high-precision positioning systems is required. Some examples are the preparation of experiments in large research facilities, optical metrology, photonics automation as well as test and calibration facilities in industrial applications. PI miCos delivers turn-key solutions from one source, even for complex integrations. All critical mechanical components are manufactured in-house at PI miCos achieving the highest performance characteristics.

The main product focus is set on robot systems for motion in six degrees of freedom, positioning technology for vacuum applications to 10^{-10} hPa, positioning systems with linear motors and air bearing technology, as well as engineering solutions for system integration.

In many fields of application, the requirements for a higher level of system integration increase. PI provides more than just high-quality components. Turn-key solutions that can be integrated seamlessly into existing processes accelerate automation in large research facilities as well as for chip manufacturing processes.



Positioning in vacuum in up to six axes



Piezo Technology: Developed In-House

PI Ceramic, PI's Piezo Manufacturing Division



PI Ceramic in Lederhose, Thuringia, Germany



Instrument for ultrasonic tartar removal, OEM product

PI Ceramic is considered a global leading player in the field of piezo actuators and sensors. The product range includes various piezo ceramic elements manufactured in both multilayer and pressing technology. Piezo ceramic components are manufactured in a large variety of shapes and sizes and come with different motion characteristics.

Prototypes and small production runs of custom-engineered piezo components are available after very short processing times.



PICMA® multilayer piezo actuators from PI Ceramic with all-ceramic coating

PI Ceramic provides

- Piezo ceramic components
- Customized and application-specific transducers / ultrasonic transducers
- PICMA® monolithic multilayer piezo actuators and benders
- PICA high-load piezo actuators
- PT piezo tube actuators
- Preloaded actuators and piezo composites



Raw materials for ceramics

Technological Developments



A profound knowledge of customer requirements and their technological feasibility is the basis for the market leadership in nanopositioning technology. With this background, PI develops positioning solutions with innovative drive technologies for high-tech applications worldwide.

- Parallel-kinematic systems for positioning in six axes (Hexapods)
- In-house manufacturing of piezo actuators
- Capacitive position sensors
- Digital control electronics
- PICMA® multilayer piezo actuators
- Comprehensive range of piezo motor technologies: PIShift® ultrasonic piezomotors, NEXLINE® high-power piezo linear drives, NEXACT® piezo linear drives, PIShift inertia drives, PiezoMike linear actuators
- Magnetic direct drives



PIMag® 6D positions and guides the passive platform with magnetic levitation

Vertical Integration and Production Capacity



Automated production of PICMA® multilayer piezo actuators in large quantities



Test laboratories for measuring accuracies down to picometers set standards



Swivel unit, capable of carrying loads to 7 t, for measurements in application situation

The product range from a two-ton Hexapod to a 10-gram nanopositioner requires that PI can both manufacture and qualify these systems.

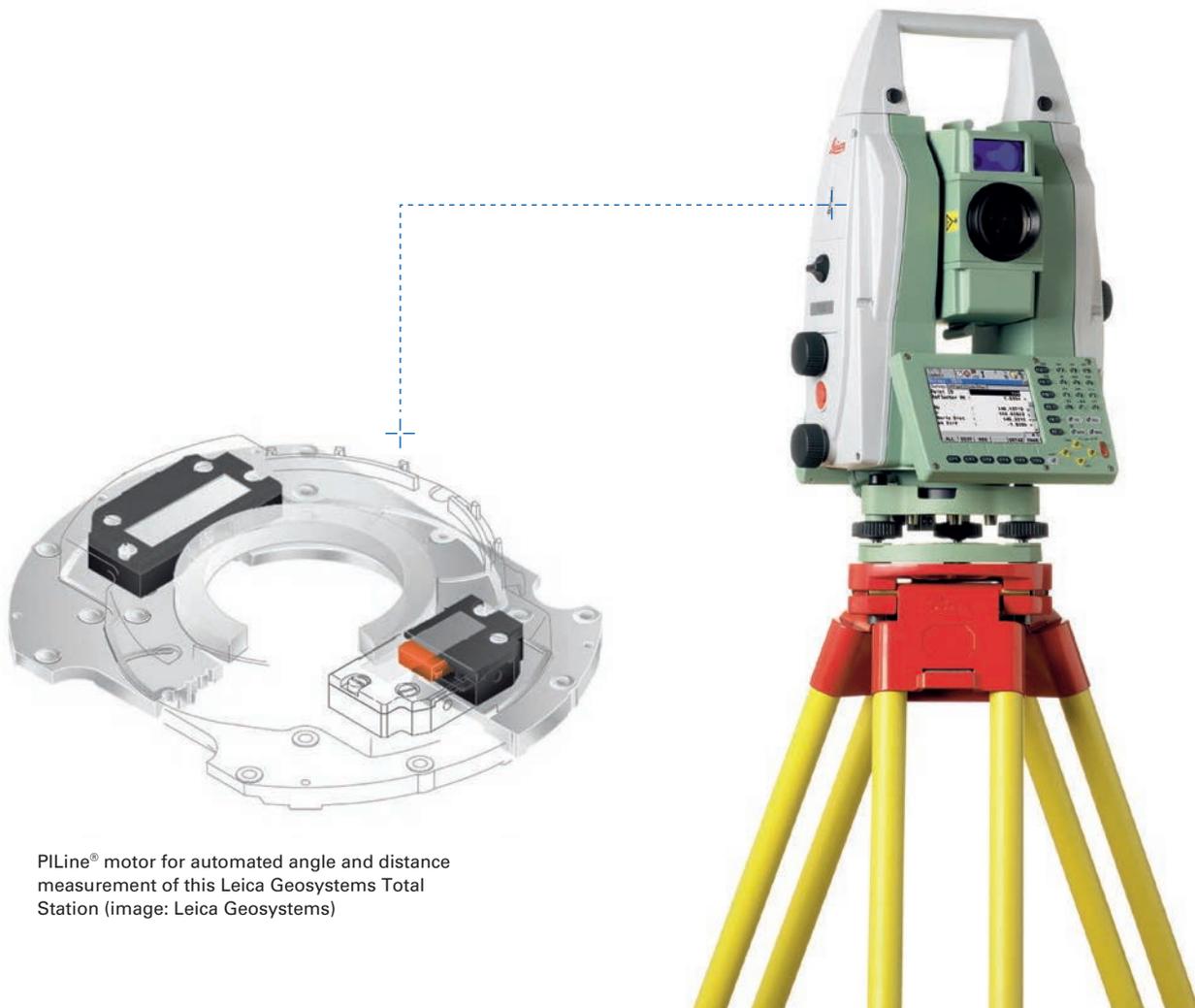
- Production and mounting at clean room conditions
- Large quantities
- Stable measuring conditions
- Traceable, calibrated measuring instruments
- Monitoring of piezo actuator technology from material composition to final inspection
- In-house production of position sensors

Competences

OEM Support

The technological range available to PI always permits different approaches not limited to one single technology right from the start. The complete control over the design and manufacturing process provides the customer with significant advantages, because PI can modify and customize its products in all areas: Drive and sensor technology, as well as control technology and software. Such solutions often go beyond the state-of-the-art, providing customers the competitive edge that is necessary to be successful in the market.

All system components are developed, produced and tested in-house, the certified Integrated Management System (IMS) ensures an efficient technical implementation.

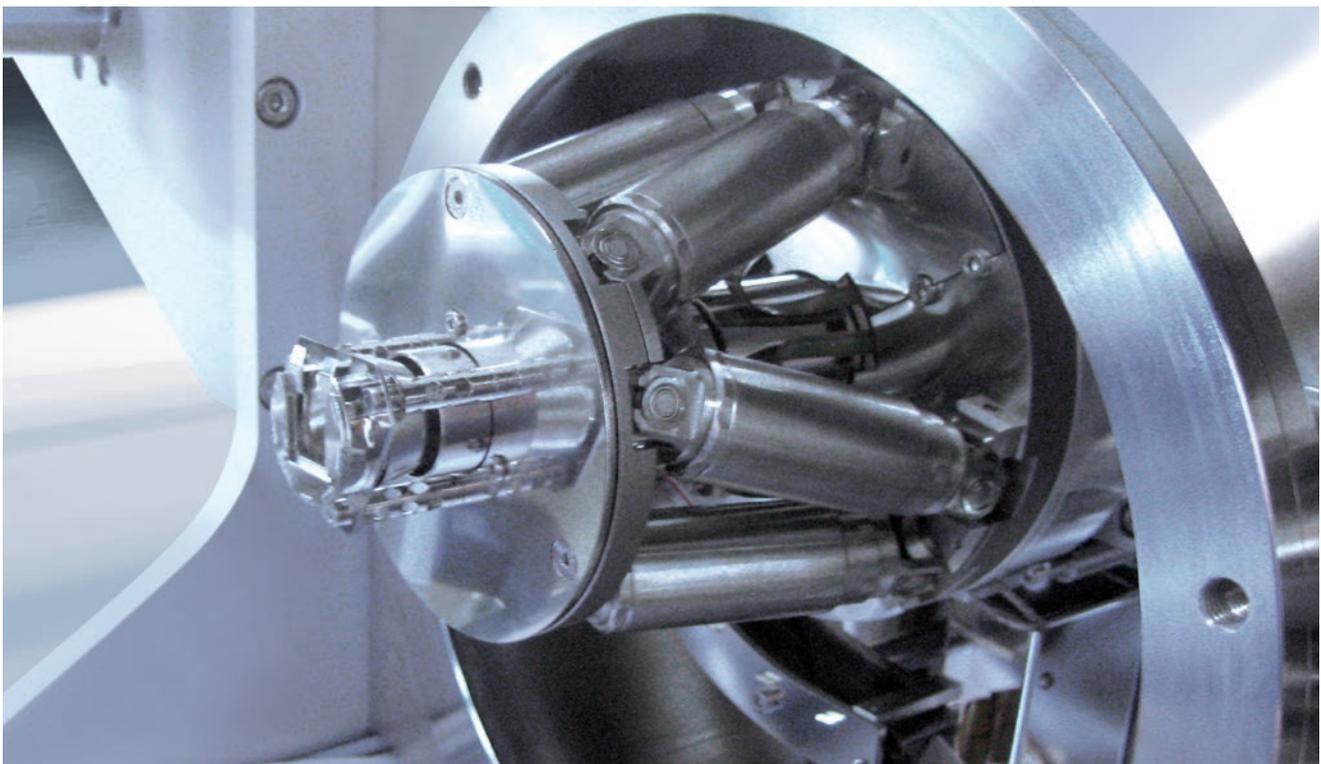


PILine® motor for automated angle and distance measurement of this Leica Geosystems Total Station (image: Leica Geosystems)

The Markets

Basic Research

Why scientists rely on PI: Creativity for Research and Development. Many scientific publications cite PI systems because they are an important prerequisite for successful research and development projects. Custom-made designs for university research are everyday business for PI, also for environmental conditions such as UHV to 10^{-10} hPa, radiation or strong temperature changes down to the cryogenic range. The spectrum reaches from completely new designs to small modifications of standard products for a better adaptation to the application. Important fields of research are, for example, beamline instrumentation, micro systems and nanotechnology.



Materials research on the synchrotron: The vacuum-compatible Hexapod from PI positions the sample in relation to the incoming X-rays (image: Surface)



PiezoMike for long-term positioning stability



Hybrid drive, consisting of electric motor and piezo actuator, for optimum positioning accuracy and minimum path deviation

The Markets

Astronomy

Positioning Solutions, Alignment

Highest precision and dynamics are required in astronomy to follow the motion of stars or to compensate atmospheric interferences. Hexapods from PI align secondary mirrors of telescopes with a precision of 1 μm or better; piezo-driven active mirrors increase the optical resolution and align the elements of large segmented mirrors.



ALMA project in the Atacama desert (image: ALMA (ESO/NAOJ/NRAO))



Space Exploration

Highest Reliability, Maintenance-Free Operation

The PI Group is currently present on Mars with micro- and nanopositioning systems: Piezo actuators separate rock

samples, motorized drives focus the camera on the Mars Rover Curiosity.

Scientific Instrumentation

High-Quality Precision Components and System Integration

- High-end equipment for scientific large-scale experiments
- System solutions
- Micro- and nanopositioners



PICMA[®] actuators in the CheMin Instrument of the Mars Rover Curiosity. 100 billion operating cycles without failures in tests carried out by NASA (image: NASA/JPL)

Automation in Emerging Technologies

Nanotechnology is already part of everyday life. The use of high-precision positioning systems in biotechnology, microscopy or semiconductor technology allows resolution of very fine structures in production and inspection. This allows production of more and more powerful integrated electronic components and investigation of new diagnostic and therapeutic methods in life sciences.



Modern lithographic method, that fully automatically realizes reproducible structures on submicrometer scales. The fine alignment of object or sample is performed by the piezo nanopositioning system (image: Nanoscribe GmbH)



Piezo nanopositioner for up to six axes



Tiny high-precision piezomotor rotary stage

Automation in Emerging Technologies

Medical Technology

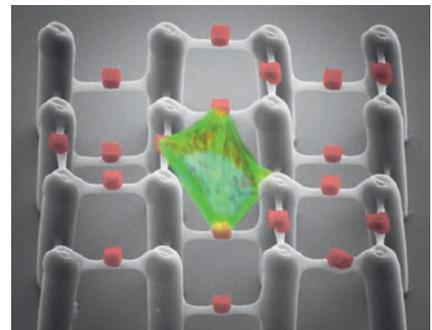
Drives for Portable Terminals, Imaging, Miniature Drives

Piezo ceramics to generate ultrasonic waves, actuators for microdosing and the production of nanoliter drops as well as miniature piezomotors for portable medication devices – all these are tasks for which the PI Group has been offering solutions for many years. For imaging processes, such as OCT, focusing or miniature zoom lenses, small and reliable drive systems are increasingly required.

Biotechnology/ Life-Sciences

Micro- and Nanopositioning Solutions

Biotechnological applications using precise positioning systems from PI are not only limited to typical optical procedures, such as focusing, or to moving and manipulation of samples in microscopy or in genome sequencers. In nanodosing and microfluidics, drive system from PI allow the dosing of smallest volumes in procedures, such as PipeJet, or the design of finest structures by means of nanoimprint or 3D lithography.



Three-dimensional structure: Cells dock on the "handles" (image: B. Richter and M. Bastmeyer, Zoological Institute, Karlsruhe Institute of Technology (KIT))

Microscopy

Positioning Objective or Sample: AFM, SEM, Optically

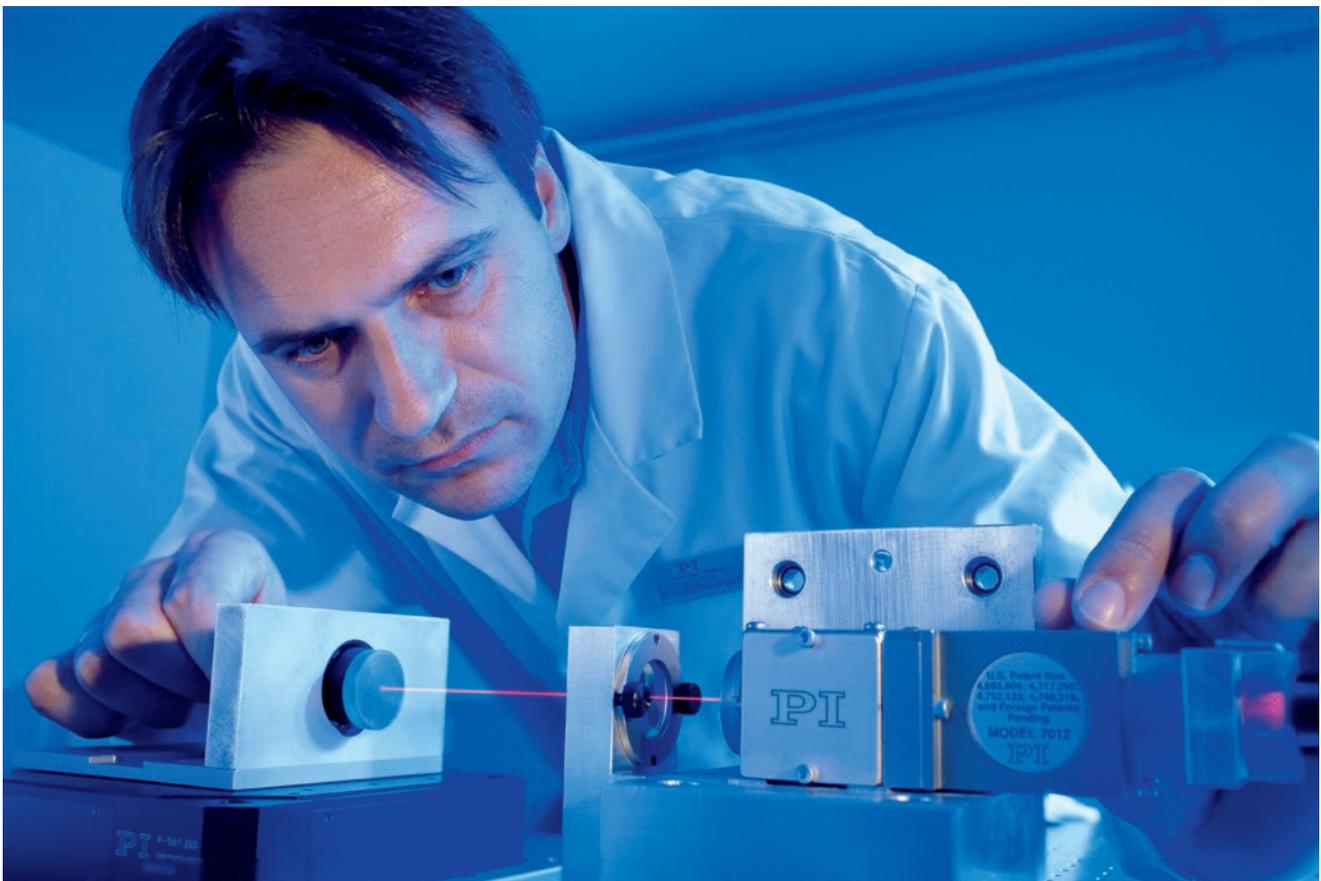
Optical methods have been relying on PI positioning systems for years, e.g. for aligning optical systems or samples. Piezo actuators and motors are increasingly replacing conventional drive systems because they are more compact, more precise and faster. Other non-optical microscopic processes, such as SEM (scanning electron microscope) and AFM (atomic force microscope), use PI systems due to their high accuracy and dynamics.



Fast scans with repeatable positioning (image: WITec GmbH)

Industrial Manufacture and Inspection

The semiconductor industry is a pioneer when it comes to commercializing nanotechnology. Modern computer chips already require structures which are only a few nanometers wide. Inspection systems in semiconductor industry use the performance characteristics of PI systems, e.g. for the inspection of surface structures on semiconductors or flat screens with white-light interferometry. Piezomotor and actuator systems from PI help to precisely align wafers, imaging optics and mask in semiconductor manufacturing.



Calibration of a multi-axis nano-metrology scanner



Piezomotor with 800 N feed force



Wafer positioner with sub-nanometer precision

Industrial Manufacture and Inspection

Optical Metrology

Fast, Precise and Repeatable Positioning

In all markets, the required tasks are focusing, zoom, object alignment and higher resolution, for applications such as conventional microscopy, digitalizing of documents or camera stabiliza-

tion for aerial photography. In all of these fields, the PI Group is present with its precise, highly stable and dynamic positioning systems.



Photonics Packaging, Silicon Photonics

Configuring and Testing Microchips



Alignment of optical fibers on a microchip in 6 axes

Silicon photonics integrate optical and electric components on silicon substrate. The resulting microchips can send data at terabit-per-second rates via optical waveguides at very low power

consumption. For manufacturing and testing components and systems, that are based on silicon photonics, precise positioning is crucial.

Mechanical Engineering

Fieldbus Interfaces, Multi-Axis Controllers, Clocked Control



Vibrations of a piezo actuator reduce the processing times for high-precision micro-sized holes (image: ICT-IMM)

- Processing, e.g. out-of-round turning with piezo actuators
- Precise positioning, even of high loads in six degrees of freedom
- Setup of testing systems

Drives that Set the World in Motion

PI is a synonym for top performance in precision motion technologies. We wish to inspire you with our products. We believe that we have exactly what it takes. PI offers a technological spectrum that is beyond competition worldwide. Piezo actuator technology, voice-coil drives, magnetic levitation technology, nanometrology sensors and digital controllers – we can implement all of these technologies for any high-precision motion task. Piezo ceramics are such an elementary part of our portfolio that we founded an entire company to produce the highest quality piezo materials in the world: PI Ceramic. This way, we are independent from general purpose components available on the market and can offer all key technologies from one source. This is what makes PI different and unique. And we need to be unique to satisfy your specific requirements in drive and positioning technology.

However, technology is not our only strength. Even more important are all the people working for and with PI. Permanent improvement of the workflow, flat hierarchies, direct communication, both internally and with our customers, are a very good basis. Our employees are looking forward to working for you. We wish to delight you with our solutions.



Dr. Karl Spanner,
President of PI



Quintessentially PI: Nanometer resolution for precision focus control in microscopy with PIFOC® objective scanner



PICMA® multilayer piezo actuators with all-ceramic coating for optimum reliability and lifetime



SpaceFAB positioning system from PI miCos. Parallel kinematics for positioning in up to six degrees of freedom

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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.