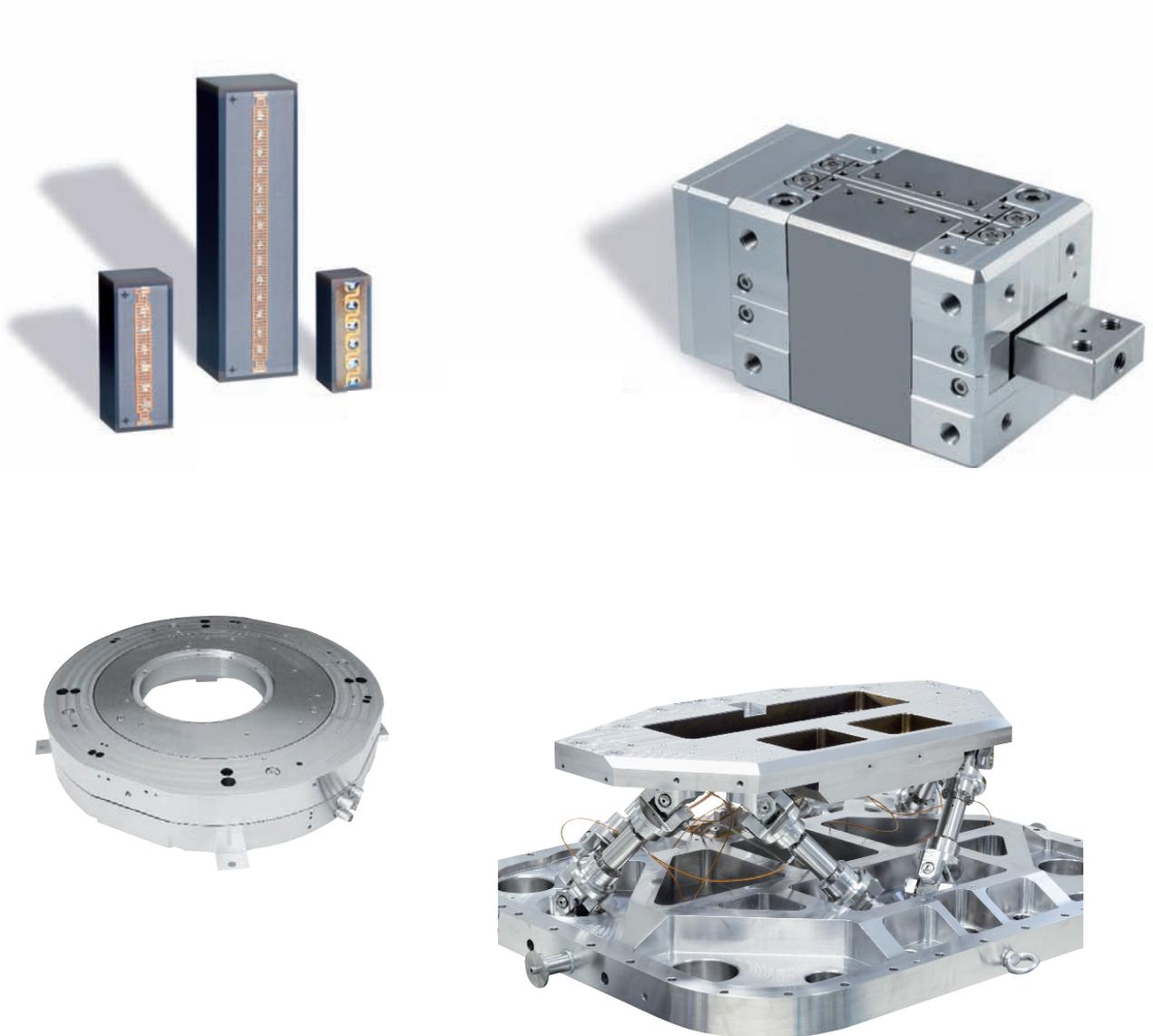


# Vacuum & Non-Magnetic Drive Technologies For Precision Positioning Applications



# Moving the Nanoworld

## NanoAutomation®: Precision Positioning for Science and Industry



PI headquarters in Karlsruhe

### Future Technology Solutions

Today PI delivers micro- and nanopositioning solutions for all important high-tech markets:

- Semiconductor Technology
- Optical Metrology, Microscopy
- Biotechnology and Medical Devices
- Precision Automation and Handling
- Precision Machining
- Data Storage
- Photonics, Fiber Optics, Telecom
- Nano Technology
- Microsystems Technology
- Aerospace Engineering
- Astronomy



PI reception desk:  
Our employees look forward to your visit

PI is market and technological leader for precision positioning systems with accuracies well under one nanometer. Nanometer-range motion control is the key to worlds where millions of transistors fit on one square millimeter, where molecules are manipulated, where thousands of “virtual slices” are made in the observation of living cells, or where optical fiber bundles no larger than a human hair are aligned in six degrees of freedom.

### Worlds We Call NanoWorlds

Continuous innovation and reinvestment of profits over the decades has allowed PI to attain its present market status. This status is also based on long-term customer relationships and on the freedom to transform ideas into reality.

### Over 30 Years Experience

When PI introduced piezo electric nanopositioning technology more than 30 years ago, typical customers were research labs and universities working on laser cavity tuning, Fabry-Perot interferometers and filters. Few foresaw that whole industrial sectors like semiconductor manufacturing or biotechnology would be come dependent on progress in nanopositioning. Today, not even the precision machining industry can do without nanometer-level positioning systems.

### Key Technologies In-House

PI follows a vertical integration strategy designed to develop and maintain all key technologies in-house. We supervise each and every step from design to delivery in the following areas: software, precision mechanics, digital and analog control electronics, sub-nanometer capacitive position sensors, piezo ceramics and piezo actuators. This assures the highest quality and reduces cost.

# The PI Group

## High Quality and Strong Brands on a Global Scale

### PI – World Market Player

As a privately run company with a healthy growth rate, over 500 employees and a flexible, vertically integrated organization, PI can meet the most diverse requirements in the area of innovative precision positioning and supply customers anywhere in the world with outstanding products.

### International Service and Sales Network

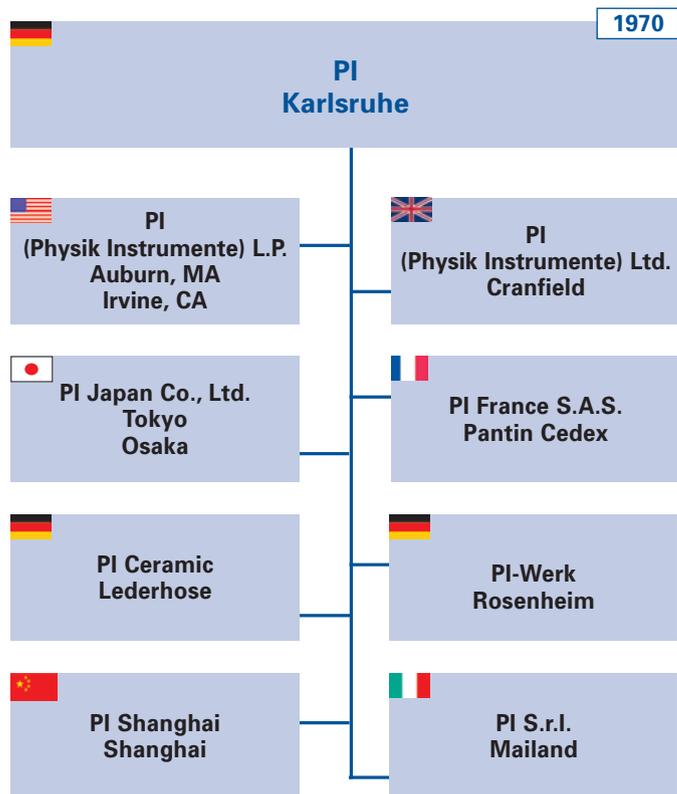
PI has established subsidiaries for sales and service in the most important local markets all over the world and maintains nanometrology test labs on three continents. In addition to PI's main R&D and manufacturing centers in Europe, PI Shanghai and PI USA provide development and manufacturing capabilities to meet the specific demands of local markets faster. In addition to the branch offices, PI has distributors in many other industrial countries. A network of highly qualified personnel around the world assures successful, long-term relationships with customers.

### Quality and Brand Policy

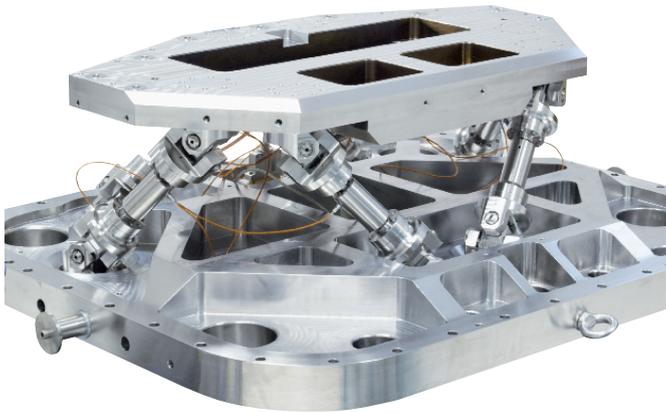
We measure the quality and reliability of our products against the strictest of standards. ISO 9001 certification, which also emphasizes points like customer expectations and satisfaction, has been accorded in 1994, making PI the first manufacturer of nanopositioning technology following this standard. PI's Integrated Management System (IMS) includes also Environmental Protection and Job Safety (according to ISO 14001:2004 and OHSAS 18001:1999). This system assures legal conformity of all procedures as well as continuous optimization of the processes at all PI locations. PI brands and colors are well known throughout the high-tech world. PIFOC® is almost used as a synonym for objective positioners in general and PICMA® stands for the highest reliability in piezo actuator products. PI stands for quality and precision – worldwide.



PI Ceramic – a PI Subsidiary – is a world-class supplier of high-performance piezoelectric actuator and transducer components and subassemblies.

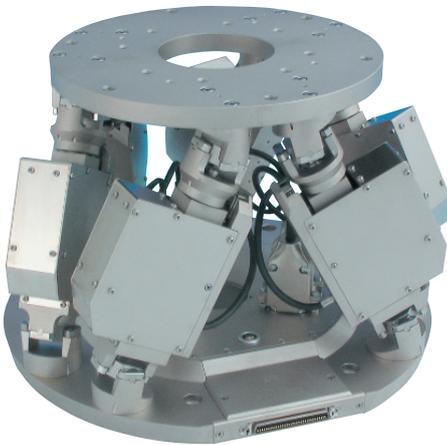


## Hexapods, Tripods – Parallel Kinematics Efficient Implementation of Multi-Axis Motion



### Non-Magnetic and Vacuum-Compatible Hexapods

- Linear travel ranges up to 100 mm
- Rotation ranges up to 60°
- Actuator resolution up to 5 nm
- Load capacity to 2000 N
- DC motors, stepper motors or piezo linear motors



PI is the leader in parallel-kinematic precision positioning systems. These advanced multi-axis systems provide many advantages over serial (stacked) positioners such as higher dynamics, stiffness and precision; and lower inertia. In a parallel-kinematics, multi-axis system, all drives act directly on the same moving platform allowing for a much more compact design, avoiding the drawbacks of accumulative runout and position errors of the individual axis. Another advantage is the lack of dragged cables completely eliminating the need for complex cable management systems.

# Piezo Actuators, Piezo Stepping Drives, Nanopositioning Non-Magnetic and Vacuum-Compatible Driving Principle

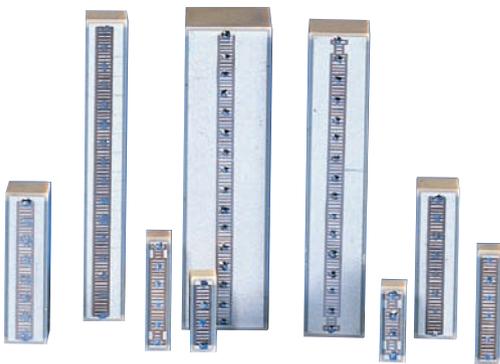
PI piezo nanopositioning systems achieve positioning resolutions, accuracy and stability in the nanometer range and below. The target position is reached within a few milliseconds. To achieve this precision, PI's patented PICMA<sup>®</sup> piezo actuators or the PiezoWalk<sup>®</sup> motors are employed. PiezoWalk<sup>®</sup> motors combine the dynamics and precision of piezo actuators with the long travel ranges of conventional motors. Integrated non-contact capacitive sensors provide picometer-precision feedback to advanced digital

## PICMA<sup>®</sup> Piezoceramic Multilayer Actuators

### Higher Reliability and Performance

- Extreme Reliability
- Large Variety of Standard & Custom Geometries
- Resolution below one nanometer
- Response time microseconds to milliseconds
- Non-magnetic and UHV-compatible

PI nanopositioning systems are equipped with the patented PICMA<sup>®</sup> piezoceramic actuators developed and produced by PI's piezoceramic division – PI Ceramic. The fully ceramic encapsulated PICMA<sup>®</sup> actuators are available in many standard and custom geometries and prove service life typically 10 times higher than conventional piezoelectric actuators.



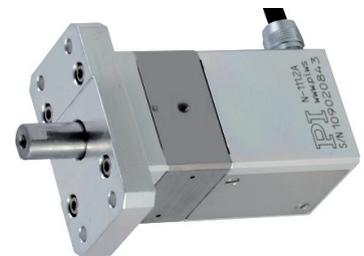
Piezoceramic material is intrinsically vacuum-compatible and non-magnetic. The displacement of the piezo actuator is based on a solid-state effect, electrical energy is directly converted into linear motion. Piezo ceramic drives do not require lubricants and are maintenance-free. High- or ultra-high-vacuum drives are used in high-resolution microscopy, nano-manufacturing, nano-lithography as well as in aeronautics and basic research.

## PiezoWalk<sup>®</sup> Linear Drive

### High Resolution over Long Travel

- NEXLINE<sup>®</sup>: Up to 600 N drive force
- NEXACT<sup>®</sup>: 10 N force and 10 mm/s speed
- Open-loop and closed-Loop operation
- Patented, Self-locking design
- Travel ranges to 125 mm, basically unlimited

PiezoWalk<sup>®</sup> drives combine the motion of several piezo actuators providing long travel ranges, very high dynamics and resolution down to the picometer range. The internally preloaded actuators automatically clamp the output shaft when powered down maintaining a stable position to within nanometers without any heat dissipation.



## Nanopositioning Systems / Piezo Flexure Mechanisms

Precision and speed in up to six degrees of freedom

- From compact linear actuators to complex 6-axis systems
- Parallel kinematics for high precision and dynamics
- Closed-loop control with capacitive direct position measurement
- Travel ranges between 1 and 1800  $\mu\text{m}$
- Large variety of loads, travel ranges and precision classes
- Non-magnetic and UHV-compatible



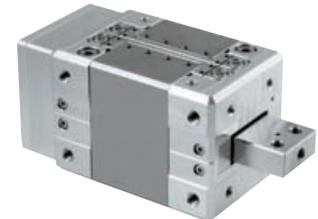
## Long Travel Ranges With NEXACT® Stepping Drives

- Travel ranges up to 30 mm
- Resolution <1 nm
- Open and closed-Loop operation
- 10 N drive force
- 10 mm/s speed
- Highly dynamic operation: >100 Hz over 5  $\mu\text{m}$
- Non-magnetic and UHV-compatible



## High Load Nanopositioning Systems With NEXLINE® Stepping Drives

- For high loads and nanometer precision
- Linear encoders with up to 5 nm resolution
- Parallel kinematics for up to 6 axes
- For chip manufacturing and inspection systems
- Non-magnetic and UHV-compatible



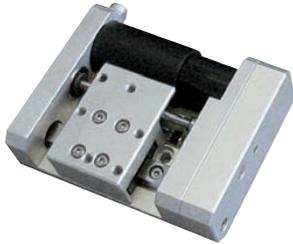
## Integrated Direct Metrology

Measure the Position Where it Counts

- Capacitive sensors: Sub-nanometer resolution
- Incremental sensors: Nanometer resolution, wide measurement ranges
- No position errors caused by indirect measurement in the drivetrain
- No position errors caused by hysteresis and play
- Non-magnetic and UHV-compatible



# Micropositioning Stages / Actuators with Ultrasonic Piezo Motors and Classical Stepper & DC Servo Drives



## Linear Positioners and Actuators

High-Vacuum Solutions for All Fields of Application

- Travel ranges between 5 and 300 mm
- From compact stages to high load positioners
- Velocity up to 150 mm/s
- Optimal incremental encoders for direct position measurement
- Versions for high vacuum

Micropositioning systems provide positioning resolution and accuracy in the range between a few tens of micrometers and 0.1  $\mu\text{m}$ . Ultrasonic piezo linear motors as well as conventional DC and stepper motors are available as drives. All units are specially prepared, assembled from vacuum compatible components and materials.

## Compact Linear Positioners with High-Speed PLine® Ultrasonic Piezo Motors

- Velocity up to 400 mm/s
- Direct position measurement with linear encoder
- Dimensions from 35 x 35 x 15 mm
- Self-locking at rest
- High-vacuum and non-magnetic versions



## Non-Magnetic Stages With PLine® Ultrasonic Piezo Motors

Ultrasonic ceramic motors are intrinsically non-magnetic and vacuum-compatible. They do not require lubricants and are significantly smaller than classical motor / leadscrew drives. Ultrasonic motors also achieve much higher velocities and faster response than classical mechanical drives and their self-locking principle provides exceptional position stability, even when powered off.



The hardbound "Piezo Nano Positioning Inspirations 2009" catalog from PI is available now. The 530 page publication is the most comprehensive reference book on the fundamentals of nanopositioning, piezo systems and micropositioning technology yet. The catalog contains 200 products with more than 1000 drawings, graphs, images and technical diagrams.

The 530 page publication presents PI's state-of-the-art products and technologies – such as:

- Nanopositioning / Scanning Stages
- Scanning Microscopy Stages
- Steering Mirrors, Mirror Shifters
- Piezo Actuators
- Piezo Motors
- Piezo Controllers
- Motorized Stages & Actuators
- Motor Controllers
- Hexapod 6-Axis Alignment Systems

The catalog also contains a tutorial on piezo technology and application examples of nanopositioning products in the following industries:

- Biotechnology / Life Sciences
- Semiconductor Technology
- Data Storage
- Nanotechnology
- Aeronautics
- Astronomy
- Adaptive Optics
- Metrology / Laser-Systems
- Precision Machining

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