Find Your Best Positioning Solution

HIGH-PRECISION MOTION SYSTEMS

Always the Right Solution for Your Application

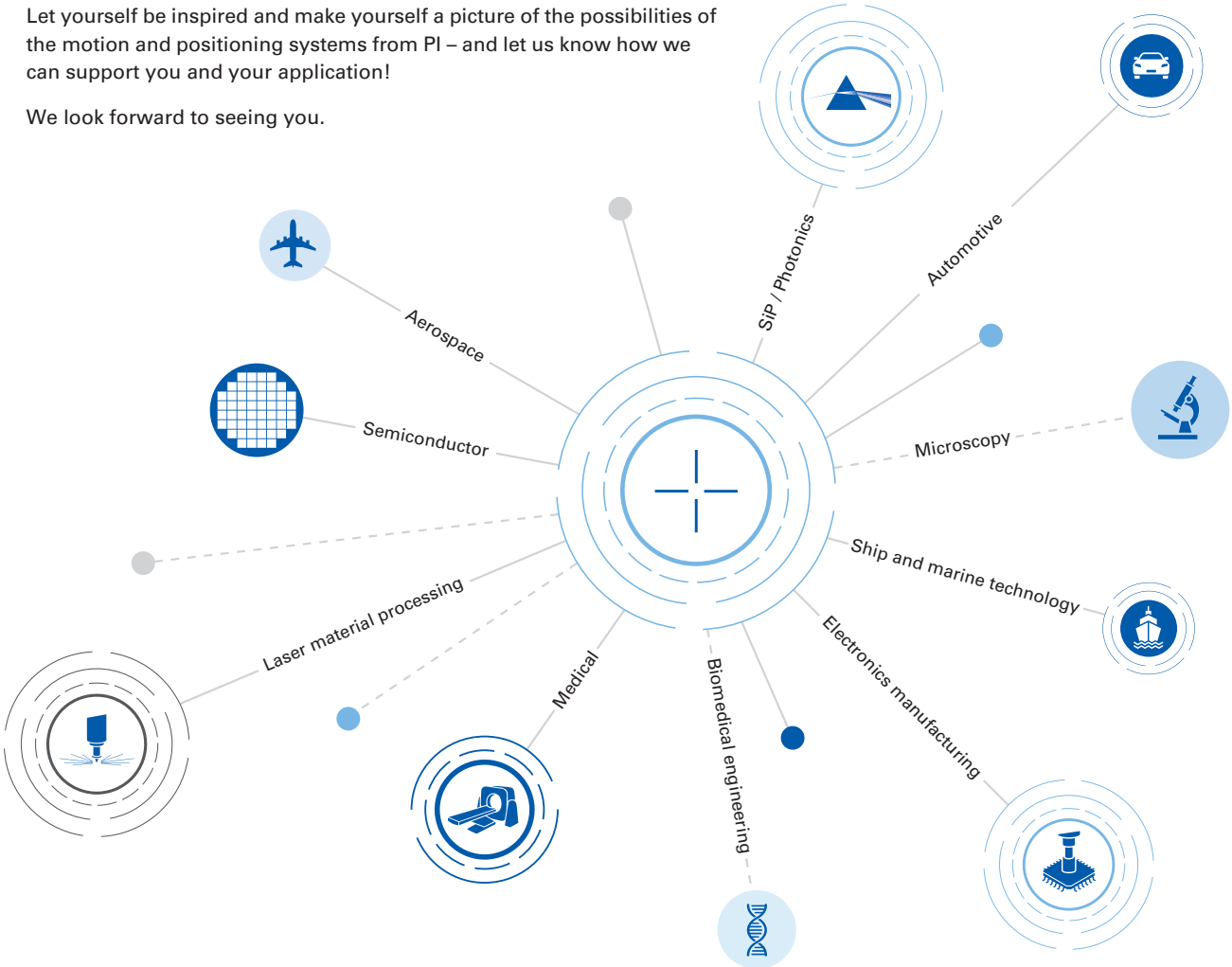
Motion and Positioning Systems from PI

High-precision motion and positioning systems are crucial for successful work in many applications. In optics and photonics, as well as in microscopy, in industrial automation – in these and many other areas, workpieces and tools move in relation to each other, samples and optics need to be aligned, or components and glass fibers are assembled permanently or for test purposes. To enable this, with accuracies down to the nanometer scale, with the required speed and reliability, this is the specialty of PI.

For this purpose, PI offers a unique, wide, and versatile selection of motion and positioning systems: From individual piezo actuators with a travel range of a few micrometers, through piezo motor-driven positioning stages, to complex gantry systems. All of this is complemented by suitable sensor and controller technology. The potential for the application of the products and solutions from PI is as diverse as the product range itself – fiber positioning systems for integrated photonic circuits (PIC); assemblies for large-area laser processing, e.g. for drilling and marking PCBs; hexapods for motion simulation to test image stabilizers; highly dynamic tilting platforms for beam control in optical assemblies ...

In this brochure we have put together a selection of solutions for different applications which you will be partly able to see live and in motion at our trade fair stands. Let yourself be inspired and make yourself a picture of the possibilities of the motion and positioning systems from PI – and let us know how we can support you and your application!

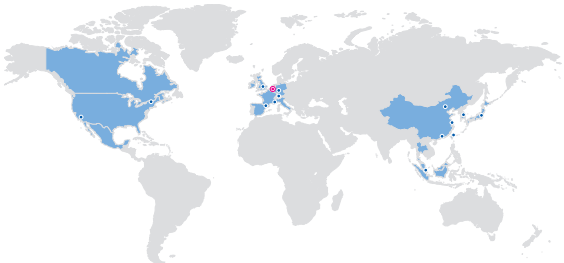
We look forward to seeing you.



CONTENT

V-731 High-Precision
XY Linear Motor Stage

H-900KSCO
Hexapod



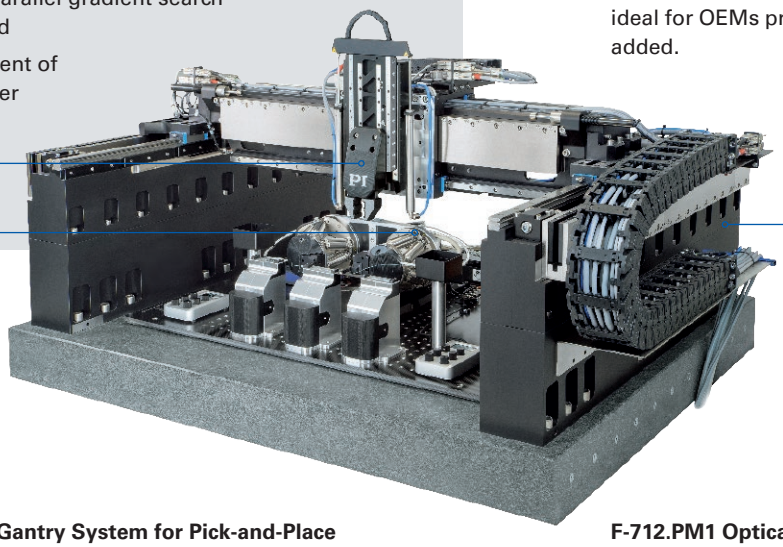
Automated Multi-Channel Fiber Array Alignment

Fast Active Alignment – Simultaneous Positioning in 6 DOF – Custom Degree of Automation

The worldwide appetite for data is growing exponentially, driven by countless applications such as mobile computing, IoT or video streaming – to name but a few. Photonics-based computing offers significant advantages in terms of lower energy consumption and faster data transmission. Cost-effective mass production of photonic integrated circuits (PICs) requires precise positioning and high alignment speed when it comes to wafer-probing, fiber-chip coupling, and packaging. The setup for multi-channel automated fiber assembly, based on the proven double-sided F-712.HA2 fiber alignment system and PI's multi-axis gantry system, offers an idea for further workflow automation.

Double-Sided Fiber Alignment System F-712.HA2

- H-811 Hexapod combined with the
- P-616 NanoCube® Nanopositioner for parallel-kinematic motion in three degrees of freedom
- Integrated scan routines for fiber optic alignment
- Firmware based parallel gradient search algorithm included
- Automatic alignment of several fibers / fiber arrays in <0.5 s



Motion Control

PI's modular hardware and ACS EtherCAT-based controller architecture allow OEMs to construct really high performance and safe automation assemblies of arbitrary complexity. Alternatively, PI's Engineered Subsystems Group stands ready to assemble and ship custom automation sub-assemblies like the one demonstrated here – ideal for OEMs preferring to focus on their value-added.

Controlled by ACS

Key Features of the Gantry System for Pick-and-Place

- High mechanical stability
- High dynamic precision positioning in three axes
- Linear motors or brushless drives (optionally with air bearings)
- Wide range of designs (drive systems, bearings, encoders …) and specifications (velocity, acceleration, travel ranges …)

F-712.PM1 Optical Power Meter

- Conversion of optical signal into a voltage signal
- Additional current input
- λ: from 400 nm to 1550 nm
- Signal bandwidth: 20 kHz
- Precise logarithmical output

Further Applications for the F-712 System Family and the Gantry Concept:

SiP / Photonics:
Waferprobing / Fiber-to-chip coupling / Test and packaging

Laser material processing:
Laser-drilling / -welding / Stencil cutting / Micromachining

Optical industry:
Lens alignment / Laser cavity tuning

Semiconductor:
Wafer- and maskinspection

Study: Fiber Alignment in Two Linear Axes Controlled by ACS

High Dynamics – Flexible Design – High Productivity

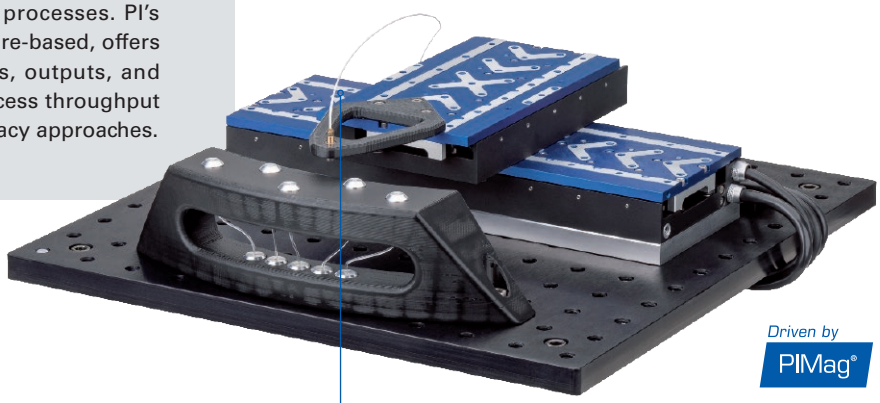
PI's optimization technology has proven to dramatically improve production economics in processes as diverse as photonics wafer probing, device packaging, chip testing, and even laser and optical equipment manufacturing. The combination of blazing speed, nanoscale performance, and industrial robustness reduces costs and improves yield worldwide. Now the flexible combination of PI's industrial stages and new alignment-enabled controls from ACS addresses additional tough throughput and yield challenges for photonics production.

This conceptual demo shows how PI's fast alignment can apply to large-area applications such as pick-and-place, and the screening, assembling, and testing of photonic devices. From the wafer, through coupon and chip, to the packaged product. The system performs a rapid localization, scanning, and fast lock-on and tracking of a series of photonic components over a large area.

This opens new possibilities for hyper-efficient systems architectures in large-format production processes. PI's unique optimization functionality is firmware-based, offers parallel alignment across multiple inputs, outputs, and degrees-of-freedom, and can improve process throughput by a factor of 100 or more compared to legacy approaches.

The Study Integrates:

- PI XY ultra-precision linear motor stage
- PI F-712.PM1 high-bandwidth, broad-spectrum optical power meter
- ACS controls with PI's alignment firmware



Motion Control

PI's modular V-508 PIMag® linear stages are ideal for the demanding manufacturing and testing of photonic devices. PI's fifth-generation fast alignment technology combined with the open-architecture modular controls from ACS enables the flexible construction of sophisticated systems, providing extraordinary performance with advanced safety provisions. These functionalities provide especially rapid throughput with seamless compatibility with today's photonic devices, which often prove challenging for legacy technologies.

V-508 PIMag® Precision Linear Stage

- Travel ranges from 80 mm to 170 mm and 250 mm
- High velocity with up to 0.6 m/s
- Acceleration up to 5 m/s²
- Crossed roller guides for high load capacity
- Compact cross section: 80 mm × 25 mm

Further Applications for the V-508 Precision Linear Stages:

Semiconductor technology:
Positioning of stages for wafer and mask metrology

Industrial automation:
Precision positioning of stages in many applications, e.g. laser material processing

High-Precision Laser Processing for Wafer Dicing

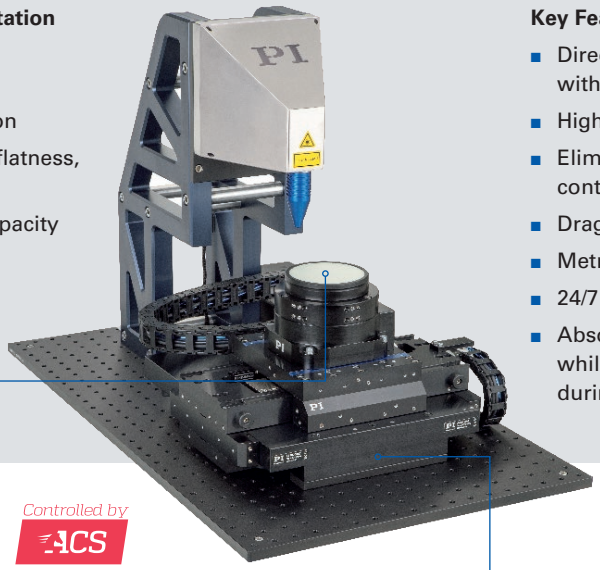
High Guiding Accuracy – Exceptional Velocity Control – High Repeatability

Manufacturing chips and microchips involves cutting the wafers, using a process known as wafer dicing, into small squares or rectangular “chips” or “dice”. Typical challenges to consider in wafer dicing applications are: To position the cut accurately, to minimize the losses of material, and to minimize distortions of the components. While at the same time, the maximum possible machining speed must be achieved. As the requirements are constantly increasing, laser dicing has become the preferred dicing technology. This noncontact laser process is flexible and avoids flaking at the cutting edges. The good quality of the edges, which is one of the decisive factors for fracture resistance, can be further improved with various automated finishing processes. This significantly reduces production waste and, therefore, saves production costs. Accordingly, laser dicing processes also demand motion systems that offer high accuracy and high straightness at high velocities.

Rotation Axis – Wafer Orientation and Correction

- Air bearing rotation stage
- Direct-drive cogless motion
- Superior travel accuracy, flatness, and wobble performance
- High stiffness and load capacity
- Cleanroom compatible

>> A-623 Plglide rotation stage with air bearings



Controlled by ACS

Key Features of the Motion Solution

- Direct-drive linear and rotation stages with air bearings for ultimate precision
- High straightness, flatness, and repeatability
- Elimination of cogging for smooth velocity control
- Drag chain cable management
- Metrology provided at wafer work point
- 24/7 operation with high duty cycles
- Absolute encoders eliminate referencing while increasing efficiency and safety during operation

Motion Control

- High performance EtherCAT® motion controller presented in a 19”-rack with integrated drives, power supplies, and functional safety

>> A-814 Plglide motion controller

- NanoPWM™ drive technology enables nanometer tracking error and optimal velocity

>> NanoPWM™ Drive

- Advanced servo control algorithms such as

>> ServoBoost™

Scan Axis

- XY planar air bearing stage
- High velocities and accelerations
- Excellent geometric performance
- Resolution to 1 nm
- Low profile for limited installation space
- Cleanroom compatible

>> A-311 Plglide planar scanner with air bearing

Further Industries and Applications That Benefit from the Motion Solution:

Laser material processing:
Ultra-fast laser ablation

Semiconductor:
Wafer scribing and singulation – Wafer inspection – Defect detection

Additive manufacturing:
Twin photon polymerization

Electronics manufacturing:
DCB (Direct Copper Bonded) circuit board scribing

Medical:
DNA luminance testing – Device manufacturing

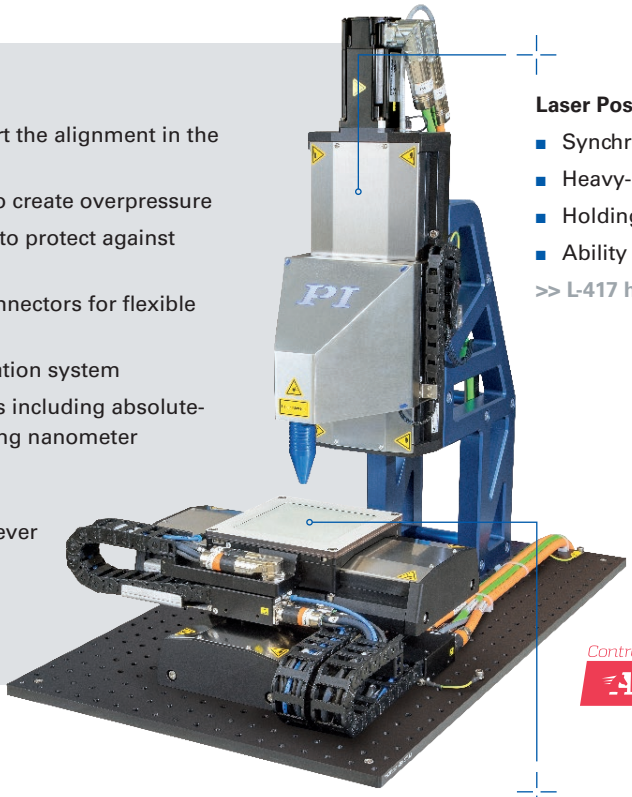
Industrial Laser Material Processing

Small Geometries – High Dynamics – Debris Protection

Machining platforms for creating tiny geometries in the micron range demand motion systems that provide a consistent, accurate and dynamic processing in multiple dimensions. As the size and mass of the manufactured parts may be challenging and particles may be formed during machining, the system components used need to be highly precise, stiff, robust and offer reliable performance.

Key Features of the Stages

- Reference edge to support the alignment in the machine
- Connector for purge air to create overpressure
- Side seal and hard cover to protect against particles
- Robust industrial IP65 connectors for flexible cable exit
- Easy access to the lubrication system
- Different encoder variants including absolute-measuring sensors offering nanometer resolution
- Different stage widths for different loads and cantilever reduction



Laser Positioning

- Synchronous servo motor
- Heavy-duty recirculating ball bearings
- Holding brake
- Ability to run directly on 110/240 volt AC

>> L-417 high-load linear stage

Motion Control

- ACS SPiiPlus EtherCAT® network motion controllers and drive modules for optimum synchronization of the axes and simultaneous control of the laser
- The Laser Control Module (LCM) can control a laser source directly with full synchronization to the motion path. LCM is able to interface with a wide range of lasers such as DPSS, CO2, excimer, fiber, Q-switched, picosecond, or femtosecond. It is also suitable for position based triggering applications for test and inspection tasks

>> Laser control module

Workpiece Positioning

- Ironless magnetic direct drive linear motors
- Heavy-duty recirculating ball bearings
- XY configuration without adapter plate
- XY drag chain cable management

>> V-417 high-load linear motor stage

Further Industries and Applications That Benefit from the Motion Solution:

Laser material processing:
Drilling – Welding

Automotive:
Fascia machining – Surface structuring – Additive manufacturing – Testing and inspection

Electronics manufacturing:
PCB Drilling – Inspection – Component placement

Medical:
Hermetic seam welding – Tissue engineering – Inspection – Metrology

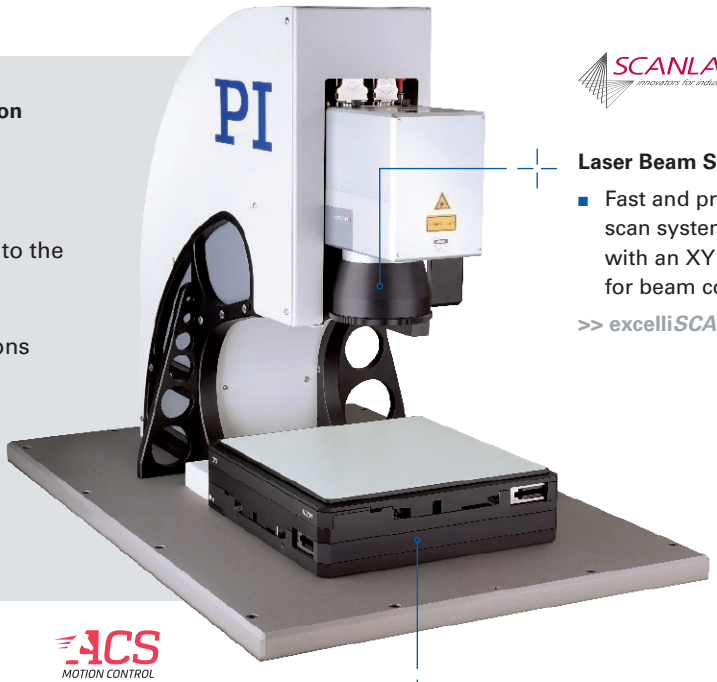
Large-Area Laser Machining

High Precision – High Throughput – Simultaneous 2-D Processing

PI offers an advanced solution to process surfaces that extend the field of view of a galvanometer scanner while maintaining resolution and spot size. The solution combines PI's high-precision motion systems, ACS's high-performance motion controller and drives, and SCANLAB's leading scanner technology. The XL *SCAN* method provides simultaneous and coordinated control of the workpiece motion system, the scanner and the laser. The control software of XL *SCAN* automatically splits the desired pattern trajectory into a path for the scanner, a path for the XY stages and the control for the laser spot. The scanner receives high-frequency motion signals for short distances. The positioning stages with long travel ranges get low frequencies and enlarge the working area. XL *SCAN* significantly improves throughput and precision in applications such as PCB drilling and large-scale laser marking. The shortened process times lead to higher productivity and lower production costs.

Features of the XL *SCAN* Automation Solution

- Extended process area
- Increased throughput
- Increased processing accuracy to the micron level
- Smooth processing with high dynamics and no stage vibrations
- Automatic laser control, e.g. Spot Distance Control (SDC)
- Multiple scan heads and workpiece motion systems capability



SCANLAB innovators for industry

Laser Beam Steering

- Fast and precise excelli*SCAN* scan system from SCANLAB with an XY galvanometer scanner for beam control

>> excelli*SCAN* scan head

ACS MOTION CONTROL

Automation Control

- Motion control solution jointly-developed by SCANLAB and ACS Motion Control which integrates a digital scanner technology using EtherCAT®-based industrial networking

>> SPiiPlus EtherCAT® motion controller and universal drive module

- Synchronization of galvo and stage motion controller achieved through

>> SLEC SL2-100 to EtherCAT® interface

- System control software which integrates the control of motion, scanner and laser at the process level

>> SPiiPlusSPC + >> sync*AXIS* control software

Workpiece Positioning

- XY linear motor stages or planar scanners for high geometric characteristics and high velocities

>> V-731 high-precision XY linear motor stage

- Optional granite support for high accuracy and stability
- Alternative gantry arrangement with stationary workpiece and moving scan head

Further Industries and Applications That Benefit from the XL *SCAN* Solution:

Laser material processing:
Micro drilling – Glass cutting – Marking

Automotive:
Surface texturing

Electronics manufacturing:
PCB drilling – PCB depaneling – Display cutting

Medical:
Tube processing

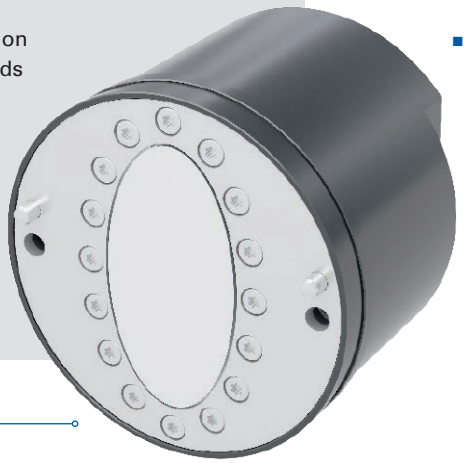
High Dynamics Focus Shift for Laser Beam Welding and Cutting

High Process Speed and Quality Through Controlled Energy Distribution

Lasers are used today in a wide variety of industrial applications in order to optimize production processes and guarantee high workpiece quality. Laser machining processes can as well be significantly improved by high-frequency oscillation of the laser beam in the XY plane. Increasing requirements in industry, however, demand not only a fast motion in the plane, but also a fast active vertical shift of the beam energy in the workpiece, e.g. to further increase the usable feed rate during laser beam cutting of thick sheet metal or to enable better weld seam quality and process stability during laser beam welding. As part of the PISTOL³ project, PI developed a piezo-based, high-dynamics Z axis focus shifter module in cooperation with the Fraunhofer IOF, the Fraunhofer IWS, and the industry partners Kjellberg Finsterwalde, Heliatek and Optics Balzers. With this module, it is possible to extend conventional methods and also 2-D beam manipulation in the XY machining plane by a highly dynamic movement in the direction of the beam axis or Z axis, thereby increasing the machining speed and improving the machining quality.

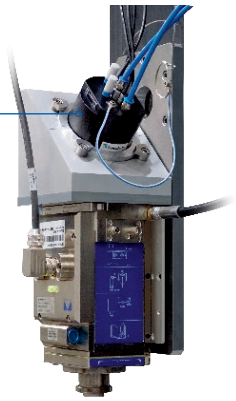
Benefits of the High Dynamics Z Axis Focus Shifter Module

- Faster process speed through controlled energy distribution in the workpiece
- Influence of the melt pool dynamics by highly dynamic oscillation of the focus position
- Compact design for easy integration into existing laser processing heads
- High reliability due to wear-free guides and actuator technology as well as process-relevant temperature management
- High economic efficiency through process optimization with low implementation effort



Preliminary Technical Data of the Prototype

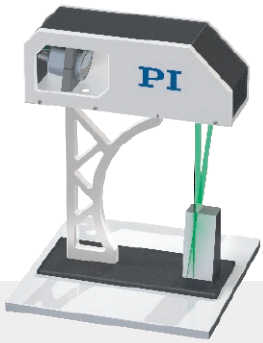
- Drive frequency to 2 kHz
- A travel range of 28 µm achieves a mean shift of the focal plane, for example, by 15 mm with an appropriate optical setup
- Versatile application possibilities due to variable module and optic design



Focus shifter module in use for high-dynamics laser cutting with 3 kW laser power

Features of the Z Axis Focus Shifter Module

- Piezo-based aspheric membrane deformation to avoid imaging errors
- Elliptical mirror substrate for maximum beam aperture exhaustion
- Dielectric coating for high reflectivity
- Use of >> PICA Thru© ring actuators



Trade fair demonstrator incl. focus shifter module

Further Applications of the Z Axis Focus Shifter Module:

- Laser beam welding
- Laser beam drilling
- Laser beam cutting
- Laser beam structuring

SPONSORED BY THE
Federal Ministry of Education and Research

The PISTOL³ project is part of the *"Zwanzig20-Partnerschaft für Innovation"* funding program that is supported by the German Federal Ministry of Education and Research, the *Bundesministerium für Bildung und Forschung* (BMBF).

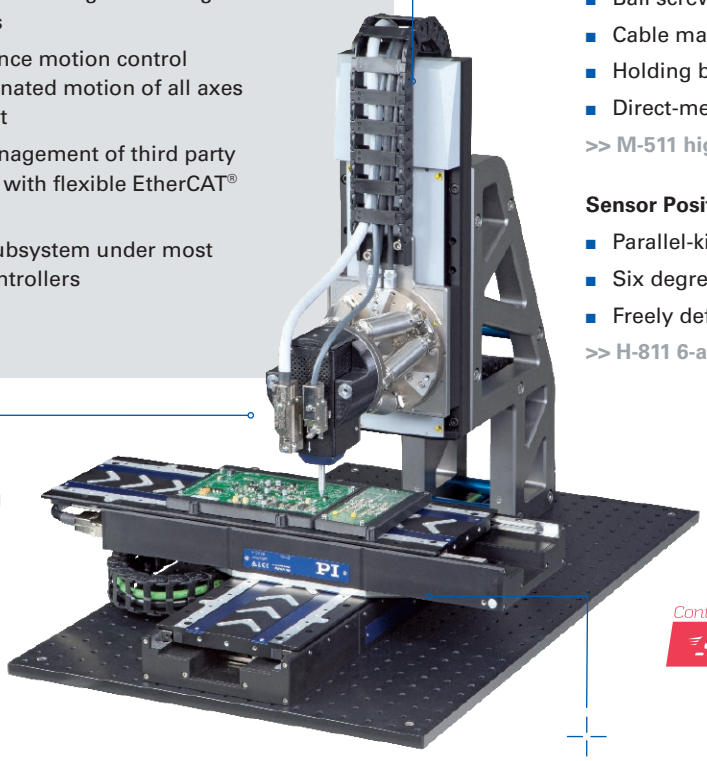
Tactile and Optical Testing of Electronic Devices

High Repeatability – Force Control – Various Angles

Electronic systems are becoming smaller, more complex, operate in different environments and include several types of devices that require tactile, optical, and electronic testing methods. The position of these devices in the final assembly demands precise positioning of the inspection tool in several degrees of freedom. PI offers high-performance motion systems for various test methods that can be integrated into customer production lines while maintaining capacity and throughput.

Key Features of PI's Motion Systems

- Unique range of motion technologies to design most advanced solutions
- Industrial high-performance motion control platform provides coordinated motion of all axes for maximum throughput
- Easy connection and management of third party sensors and test devices with flexible EtherCAT® connectivity
- Can be integrated as a subsystem under most PLCs and automation controllers



Positioning of Testing Device

- Ball screw linear motor or voice coil stage
- Cable management integration
- Holding brake or counterbalance
- Direct-measuring linear encoder

>> M-511 high-precision linear stage

Sensor Positioning at Various Angles

- Parallel-kinematic hexapod
- Six degrees of freedom
- Freely definable center of rotation

>> H-811 6-axis miniature hexapod

Force Control of Measuring Sensor

- PIMag® voice coil linear actuator
- Force sensor with 1 mN resolution

>> V-275 PIMag® voice coil linear actuator

Controlled by ACS

Automation Control

ACS SPiiPlus EtherCAT-based motion control platform operates as an independent machine controller or as a subsystem under most PLCs and automation controllers

- Motion Controller >> SPiiPlusES
- Universal Servo Drives >> NPMpm

Workpiece Positioning

- Magnetic direct drive linear motors for high precision and high velocities
- Absolute encoder with 1 nm resolution
- XY drag chain cable management

>> V-551 precision linear motor stage

Further Industries and Applications That Benefit from This Stage and Motion Control Concept:

Electronics manufacturing:
Fingerprint and pressure sensor testing – Camera lens alignment – Haptic tests

Automotive:
Testing of inclination, velocity, and acceleration sensors – Lens alignment – Injection nozzle inspection – Haptic tests for car keys

Laser material processing:
Hermetic seam welding – Surface texturing

Semiconductor:
X-ray and computed tomography inspection

Medical:
Surface profiling of spherical and aspheric lenses – Needle inspection

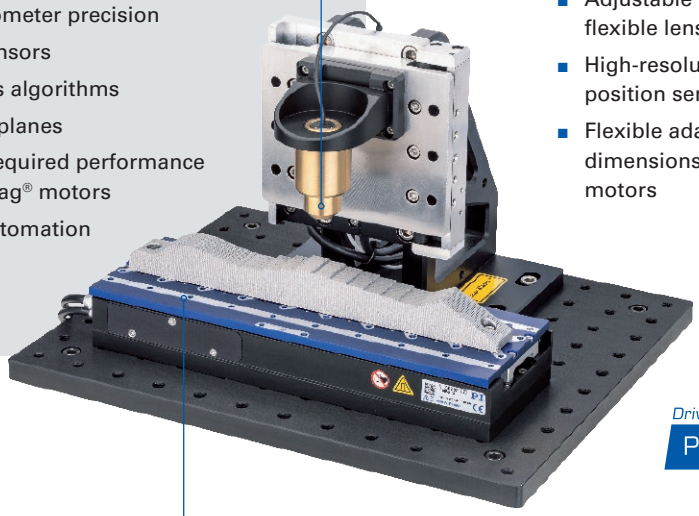
Industrial Optical Inspection

Flexible Configuration – Fast Step-and-Settle – Nanometer Resolution

Optical inspection is an essential process in industrial quality assurance. Optical inspection systems, which are used in industrial environments, should provide reliable and repeatable measurement results and enable high throughput rates. This also applies to the movement of the workpiece, specimen or test specimen, and to the positioning of the imaging optics. The positioning systems used must be flexible in order to move both the sample in the plane along different travel ranges and the optical components in the vertical direction.

Key Features of the Positioning Solution

- Flexible configuration
- High repeatability and nanometer precision
- High-resolution position sensors
- Measuring using auto-focus algorithms
- Focusing on different focal planes
- Flexible adaptation to the required performance characteristics through PIMag® motors
- Easy integration into the automation environment via industrial EtherCAT® interface



Driven by PIMag®

Positioning of the Imaging Optics

- High scanning speed and fast step-and-settle due to magnetic plunger coil drive
- Adjustable weight compensation for flexible lens masses
- High-resolution, direct-measuring position sensors
- Flexible adaptation of drive force and dimensions due to PIMag® voice coil motors

Sample Positioning

- High scanning speeds due to magnetic linear motors
- Serial axis combinations for flexibly configurable travel ranges on the sample level or integrated XY stages for space-saving design
- High-resolution, direct-measuring position sensors
- Flexible adaptation of drive force and dimensions due to PIMag® linear motors

>> V-508 PIMag® precision linear stage

Motion Control

- Optional industrial EtherCAT® interface
- Digital control with optimized control algorithms for constant scanning speed, high repeatability, and fast step-and-settle
- Fast sensor signal processing for simultaneous high speeds with high resolution
- Optional analog inputs for external control signals

Further Industries and Applications That Benefit from the Motion Solution:

Biomedical engineering

Electronics manufacturing

Flat-panel production

Microstructure technology

Laser material processing

Semiconductor

Microscopy

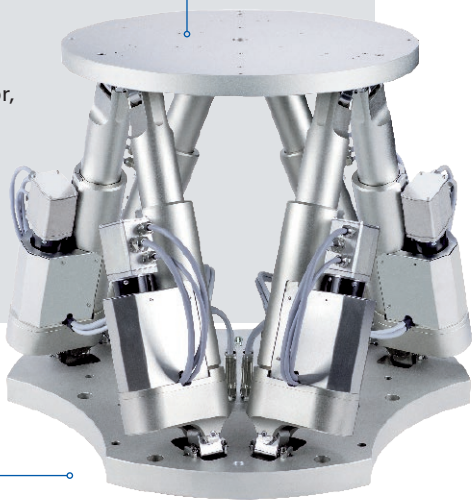
Motion Simulation for Qualifying Gyroscopes

Multiple Degrees of Freedom – Highly Dynamic Following of Predefined Trajectories

Gyroscopic instruments or gyroscopes can detect and measure a rotary motion or acceleration of the external reference system in relation to the rotating mass. For example, built into theodolites they are used for precise measurements in geodesy, mining, or geology. Due to their properties, gyroscopes are also used for active attitude control in aerospace and marine applications. The ISS space station, for example, uses the gyrocompass to determine its position in space. Even many smartphones have a built-in gyrocompass for navigation and location. In order to qualify gyrocompasses, real conditions such as ship movements must be simulated. ISO standards exist that describe the motion profiles and performance requirements in detail for these test procedures. The combination of reaching a target position with a certain precision and the translational and rotational movements (roll, pitch, yaw) is a challenging task that can be performed by specifically designed hexapods.

Key Features of Hexapods

- Three linear axes, three rotational axes
- High stiffness
- Excellent dynamic behavior, fast step-and-settle
- Excellent repeatability
- No cable management at the motion platform required



Motion Simulation Applications Benefit from:

- Multiple degrees of freedom
- Freely definable center of rotation
- Tracking of predefined trajectories
- Motion frequencies to 50 Hz*
- CIPA certification*

>> Image shows the H-900KSCO hexapod

* depending on the hexapod used

Motion Control

- Easy commanding of target positions in Cartesian coordinates
- Coordinate transformation for parallel kinematics is handled by the controller
- Reference system (work, tool) can be quickly and easily changed
- Definition of sine curves and/or arbitrary trajectories
- Support of motor brakes and absolute-measuring sensors with BiSS interface
- Analog input available
- Easy integration in automation processes via industrial EtherCAT® interface

>> C-887.53x hexapod motion controller with EtherCAT®

Further Industries and Applications That Benefit from Motion Simulation with Hexapods:

Ship and marine technology:
Gyrocompass testing according to ISO 20672, ISO 8728, and ISO 16328

Quality assurance:
Testing of image stabilization systems of cameras – Testing of gyroscopic sensors of smartphones

Automotive:
Testing of vibration resistance – Testing of cameras for driver assistance systems

Motion Simulation for Testing Image Stabilization

High Repeatability – High Dynamics – High Path Accuracy

Taking sharp pictures despite poor lighting conditions, taking snapshots without blurring, recognizing traffic signs or road markings in driver assistance systems, or identifying dangerous situations in surveillance systems – all of this is possible today with the help of modern cameras. But how good is the still and video image quality of a camera or smartphone? End users, manufacturers from companies in the aerospace, medical and security, or the automation technology sectors – they all place high demands on the performance capabilities and look for answers to these questions. Companies dealing with these issues rely on test equipment that guarantees reliable and comparable test results. In order to test the image stabilization systems of cameras, for example, the frequencies and axis movements must be simulated realistically and they must be identical for each test.

Key Features of the Hexapod

- Three linear axes, three rotational axes
- High stiffness
- Excellent dynamic behavior, fast step-and-settle
- Excellent repeatability
- No cable management at the motion platform required

Motion Simulation Applications Benefit from:

- Multiple degrees of freedom
- Freely definable center of rotation according to the position of the image stabilization component in the camera
- Excellent dynamic behavior
- Tracking of predefined trajectories
- Motion frequencies to 50 Hz*
- CIPA certification*

>> Image shows the H-840 hexapod

* depending on the hexapod used

Motion Control

- Position input via Cartesian coordinates
- Coordinate transformation handled by the controller
- Reference system (work, tool) can be quickly and easily changed
- Definition of sine curves and/or arbitrary trajectories
- Support of motor brakes and absolute-measuring sensors with BiSS interface
- Analog input available
- Easy integration in automation processes via industrial EtherCAT® interface

>> C-887 hexapod controller with EtherCAT®

CIPA Certification

The lobby association of the Japanese photographic industry Camera & Imaging Products Association (CIPA) sets standards for motion systems that are used in test equipment for image stabilization. Hexapods from PI are the only six-axis positioning system for the simulation of camera shake that fulfill the requirements of the CIPA standard.

Further Industries and Applications That Benefit from Motion Simulation with Hexapods:

- Camera manufacturer
- Aerospace
- Security
- Automotive
- Medical
- Machine vision

Fast Platform for Mirror Tilting

Short Settling Time – High Dynamic Linearity – Parallel-Kinematic Design

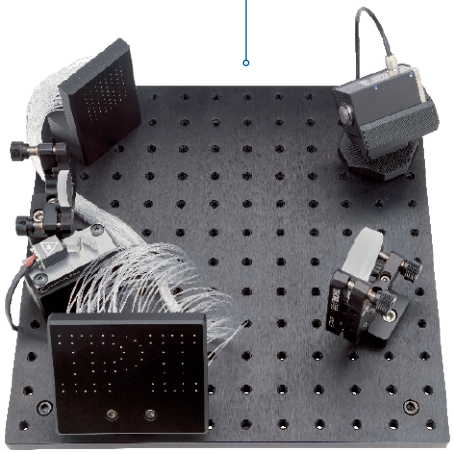
Dynamically adjustable mirrors play an important role in countless optical structures. Examples are image processing and stabilization, optical filters and switches, optical traps, laser tuning, and many more. The S-355 tip/tilt platform is versatile in use thanks to its parallel-kinematic, multi-axis design and its flexure guides, which are free of maintenance, friction, and wear. It allows fast, high-dynamics motion with high precision.

Key Features of the S-335 Tip/Tilt Platform

- Tip/tilt angle to ±17.5 mrad ➔ high optical deflection angle to 70 mrad (4°)
- Parallel-kinematic design: Two orthogonal rotational axes with one common center of rotation
- High resonant frequencies from 2 kHz (unloaded) to 0.7 kHz (loaded with 1 inch mirror) for dynamic motion and fast step-and-settle
- Integrated strain sensors for high linearity

E-727.xF Digital Multi-Channel Piezo Controller with Ethercat® Fieldbus Interface

- Simultaneous control of up to 3 axes
- 20 kHz sampling rate for control
- 100 kHz sample rate for sensor reading
- ID chip support for automatic calibration of the controller to the piezo mechanics (fast startup and interchangeability of system components)



Light Coupling in Fiber Matrix

- High-precision beam control for coupling of laser light in individual glass fibers for the generation of dot graphics with the highest demands on precision and speed

Range of Applications for Tip/Tilt Platforms:

Optical industry:
Pointing applications with highest demands on linearity and point-to-point accuracy / optical trap / image stabilization

Semiconductor technology:
Beam steering during wafer and mask inspection, lithography

Microscopy:
Multicolor applications

SiP / Photonics:
Alignment and assembly processes

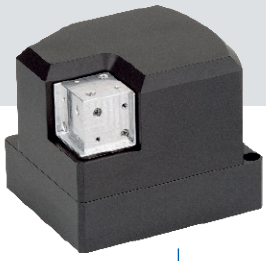
Object Positioning in Six Degrees of Freedom

Parallel-Kinematic Design – Travel Range to 500 µm / 1.5° – Nanometer Precision

Performing object movements in all six degrees of freedom is necessary in many applications. For example, the alignment of lenses in complex optical systems (e.g., smartphone cameras) or the positioning of optical fibers on silicon photonic components. New active alignment applications place higher demands on the positioning accuracy. Tolerances are not only limited to the three spatial directions, the angle accuracy comes into focus and so angle scans become necessary, for example. The compact, parallel-kinematic P-616KLTS NanoCube® serves all six degrees of freedom and opens up many new possibilities for the assembly and adjustment of demanding structures.

Key Features of the P-616KLTS NanoCube®

- 500 µm travel range in X, Y, and Z
- Tip/tilt angle to 1.5° in θ_X, θ_Y, θ_Z
- Any pivot point
- Complete parallel-kinematic design

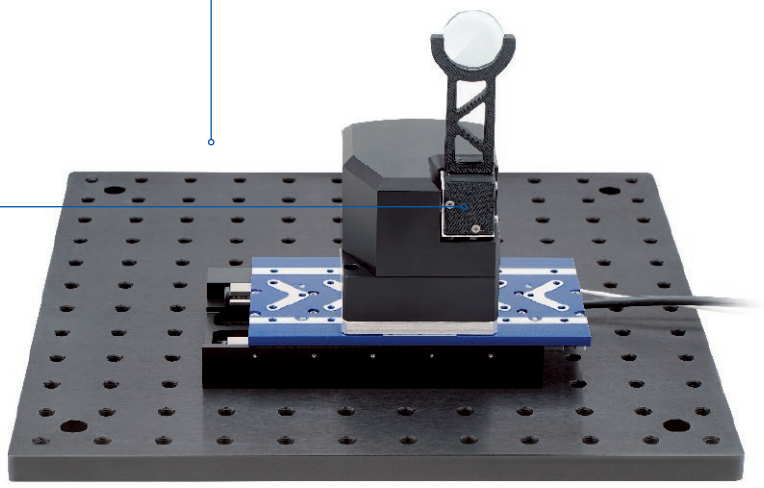


E-712 Digital Piezo Controller

- Modular digital controller for multi-axis piezo nanopositioning systems

Positioning of Lenses in Six Degrees of Freedom

- The requirements for camera systems in smartphones are continuously increasing. In addition to higher resolution, users expect a true optical zoom, sharp and distortion-free images, image stabilization, and much more. In order to meet these requirements, the individual elements of a lens must be aligned with high precision along the optical axis and with respect to each other. With the new P-616KLTS NanoCube® with six degrees of freedom, completely new alignment strategies become possible to meet these requirements.



Range of Applications:

Optical industry:
Precision positioning of optical elements (lenses, gratings, plates ...) in six degrees of freedom

SiP / Photonics:
Fibre positioning / wafer probing / chip test / test and packaging

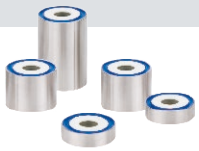
Active Shims for Long-Term Stable Positioning

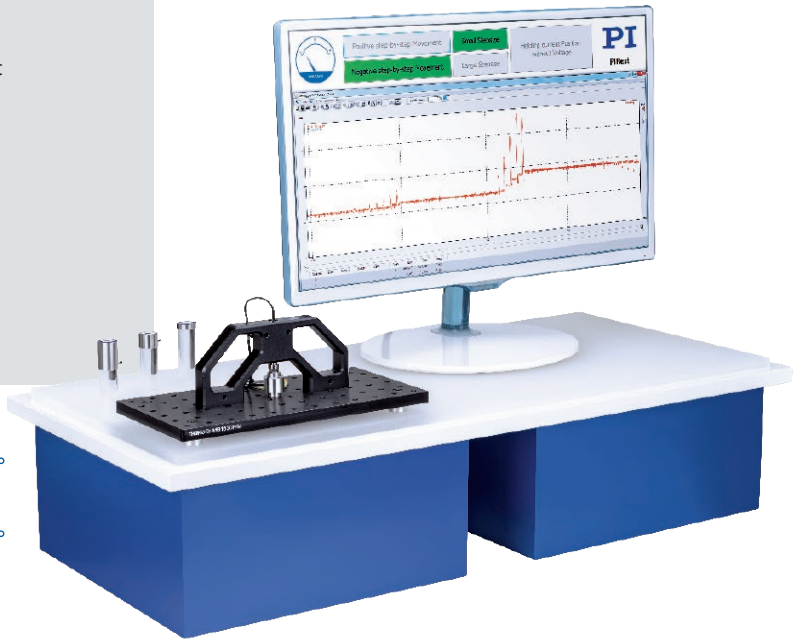
Nanometer Precision – High Load Capacity – Long-Term Stability

If a dimension between two components or subsystems inside precision machines or in complex test assemblies changes, readjustment may often be necessary. PIRest active shims, the piezo-based "washers", offer a simple solution for it. Once they have been installed in the machine, the distance between two components or machine parts can be readjusted with their help and without any further assembly as often as required and with nanometer precision. These PIRest actuators have a high load capacity and they are long-term stable. This helps to reduce the installation time of high-precision machines and optical assemblies and it also reduces downtime, particularly in difficult to reach places (in vacuum chambers or inside machines). If active shims are already designed into the machine during initial construction, it already helps to save time and costs during the first adjustment.

Key Features of the PIRest Actuators

- Nanometer resolution, micrometer displacement
- A permanent voltage supply is not required to maintain the position
- Long-term position stability
- Load capacity up to 4000 N per actuator
- Flexible shapes and dimensions
- Can be combined with classical piezo actuators for static error correction in dynamic processes





E-135 PIRest Drive Electronics

- Control of up to 6 PIRest active shims
- ID chip detection for automatic configuration of operating parameters
- Independent adaptation of operating parameters to the ambient conditions

Demonstration of Long-Term Stable Positioning with PIrest Actuators

- Reversible adjustment
- Different incremental motion
- Allows expansion and contraction
- Long-term position stability without permanent voltage

Range of Applications for PIRest Actuators:

Semiconductor technology:
Adjustment of machine parts or optical components in wafer scanners / wafer probes

Beamline (e.g., synchrotron):
Long-term stable alignment of complex experimental setups

Mechanical engineering:
Alignment of machine bed, motors, axes, and other machine elements

Optical industry:
Long-term stable precision alignment of single lenses in the system

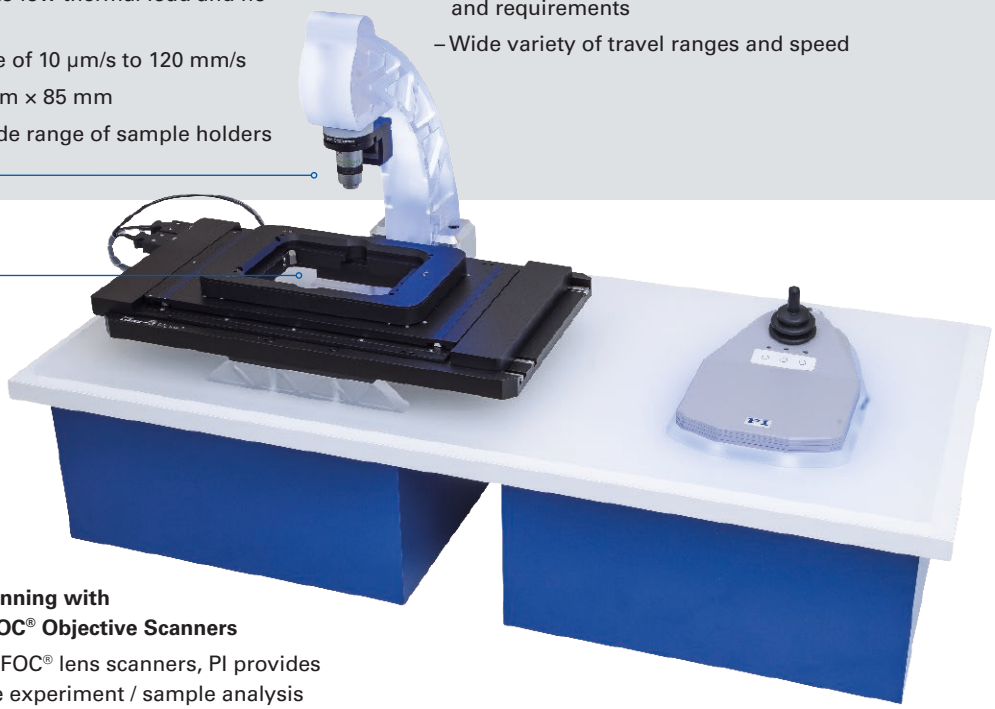
Nanopositioning for Microscopy

Fast – Compact – To the Nanometer

Precision Positioning is the key element in all types of microscopy. High resolution microscopy must be capable of accurate and reproducible positioning of imaging elements and samples. Requirements range from z-focus positioning of the objective to coarse and fine positioning of the sample in X, Y and Z-direction as well as often in θ_X and θ_Y direction and sometimes even in θ_Z. PI meets these requirements with a broad product portfolio for inverse microscope systems of all major manufacturers.

Coarse and Fine Positioning Sample Stages

- U-780 PILine® XY Stage System with Controller and Joystick
  - High-resolution piezo linear drive
  - Self-locking at rest, low noise
  - Highest stability due to low thermal load and no lubricants
  - Large dynamics range of 10 µm/s to 120 mm/s
  - Travel range to 135 mm × 85 mm
  - Compatible with a wide range of sample holders
- Large selection of fine positioning stages for positioning of samples (sample holders) in the nanometer range
  - Positioning with (sub-)nanometer precision in one (Z) direction or in many DOFs; depending on the model and requirements
  - Wide variety of travel ranges and speed



Focusing and Z-Stack Scanning with Nanometer Precision: PIFOC® Objective Scanners

- With a wide range of PIFOC® lens scanners, PI provides the ability to do just the experiment / sample analysis you want to perform.
- Latest developments comprise the newly designed PIFOC® P-725.1CDE2 with improved settling times.

Applications for the Sample Positioning Stages:

Microscopy:
Super Resolution Microscopy
3-D Surface Inspection
Digital Slide Scanning
SEM/AFM

Further Applications for the PIFOC Scanner:

Electronics Manufacturing:
Screening
Autofocus Systems
Surface Analysis
Metrology

Services from PI

Support Services – Extended Warranty – PI Express Service

PI is dedicated to supporting its customers right from the initial consultation through to when a customer has purchased a PI system. Beyond that, PI's services division is committed to ensuring that every aspect of owning a PI system is catered for. Supported by four Global Service Hubs in Asia, China, Europe and USA, with field product specialists working from these hubs, PI is able to support all technologies and customer applications via this global services team. PI has different service types in addition to the standard service offered today. The services are described below and can be tailored to each customer's specific needs.

	Standard Support	Extended Warranty	Extended Warranty PLUS	PI Express	PI Express PLUS
24 Months Warranty (Parts and Labour cover for manufacturing defects)	✓	✓	✓	✓	✓
Access to PI's Service Support Desk (TRT = Target Response Time) Standard Working Hours 8:00 –16:00	Regional Support For 2 Years TRT <12 working hours	Regional Support For up to 5 Years TRT <12 working hours	Regional Support For 3 Years TRT <12 working hours	Regional Support For up to 5 Years TRT <4 working hours	Regional Support For up to 5 Years TRT <4 working hours
Extended Warranty (Parts and Labour costs covered for manufacturing defects – 1, 2 or 3 additional years)		✓	✓	Optional	Optional
Extended Warranty PLUS (Extended warranty, plus cover for replacement parts that fail due to normal Wear and Tear.*)			✓	Optional	Optional
Extended Hours Support (Access to PI's Global Support team providing ad hoc planned out of hours support services)				✓	✓
Highest Priority Remote & On-Site Support**				✓	✓
Spares Holding (Dedicated holding of spare parts/ systems to minimise unscheduled downtime)					✓

Standard Support

This is the service level that all customers receive today. PI will respond to any customer's support request whether inside or outside of a valid warranty period. PI's remote support service is free of charge and while products are under warranty, customers benefit from a 12 working hour target response time, from the initial customer contact.

Extended Warranty

PI's Extended Warranty delivers wrap around protection for customers with the option to extend the product warranty cover period for up to 5 years. Extended Warranty can provide cost protection from any latent defects, service level response times for support enquiries and priority service for warranty repairs and fault analysis.

PI Express Service

PI's express subscription is the highest priority support service. If a customer experiences a product failure, PI will provide express remote support, express on-site response if required and can also ship out a dedicated spare system, to get the customer operational again as quickly as possible.

>> More information about PI services at www.pi.ws/service

* A normal wear and tear failure is defined as damaged that has been caused due to ordinary use. Wear and tear failures that are excluded for non-ordinary use might be where the system has been exposed to radiation; liquid or third party abrasive particles have entered the mechanics; the application or operation is beyond the stated capacity of the system (orientation, load, travel limits, environment); or where user error or an external force has been applied that caused the failure. Maximum 2 claims over the 3 year term.

** All on-site services are chargeable in advance at the on-site rate depending on customer location.

The PI Group

A Strong Partner for Industry and Research

PI (Physik Instrumente) has been one of the leading players in the global market for precision positioning technology for many years. The technological diversity of the PI Group is unique all over the world. PI develops, manufactures, and qualifies all its core technologies itself. PI is therefore not dependent on components available on the market to offer its customers the most advanced solutions.

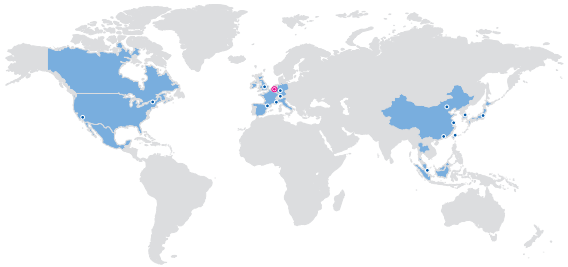
The complete control over vertically linked manufacturing processes allows flexible reaction to market developments and new requirements.

Modern organizational forms such as the fractal production model guarantee efficient production for batch sizes of 1, small series, and also OEM products in large quantities. By acquiring the majority shares in ACS Motion Control, a worldwide leading developer and manufacturer of modular motion controllers for multi-axis drive systems, PI can also offer solutions from one single source to meet the industry's increasing demands on precision and throughput.

The foremost priority for PI is to be a reliable and highly qualified partner for the customer.

Core Technologies

- In-house manufacturing of piezo components and piezo actuators
- Magnetic direct drives: linear motors and voice coils
- Air bearings, magnetic and flexure guides
- Comprehensive range of piezo motor technologies
- Nanometrology sensors
- Parallel-kinematic systems for positioning in six axes (Hexapods)
- Motion control technology
- Software



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