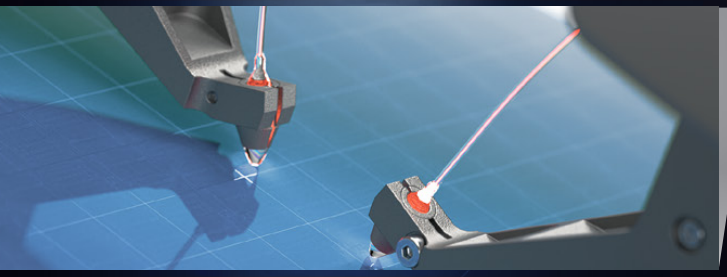
PI

»DRIVING INNOVATION

Photonics



Wafer Inspection

Laser Drilling

Thinking Beyond to Reach the Next Level of Precision

In Motion Control, Nanopositioning, and Automation

Innovation involves taking risks, challenging conventional thinking, and pushing boundaries to discover new possibilities. It drives progress. It paves the way for positive change. At PI, we enable excellence with thorough knowledge and decades of expertise, extensive skills, and that intangible element—the spark of innovation. We have created a dynamic ecosystem to encourage the generation of new ideas and solutions. Every day, we transform ideas into tangible outcomes that make a difference. Giving room to curiosity and creativity, exploring new technologies and inviting collaboration, taking risks and learning from mistakes, addressing challenges, and solving problems: This is where innovation starts.

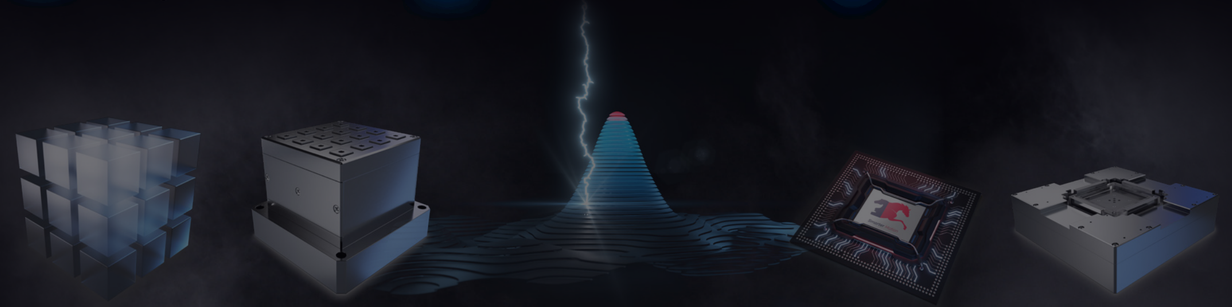
PI. Driving Innovation.

Start your digital experience and get inspired by our innovations

Our Core Technologies

PI's portfolio is based on several core technologies reflecting our commitment to providing innovative solutions for precision positioning and motion control. For numerous applications, in various industries.

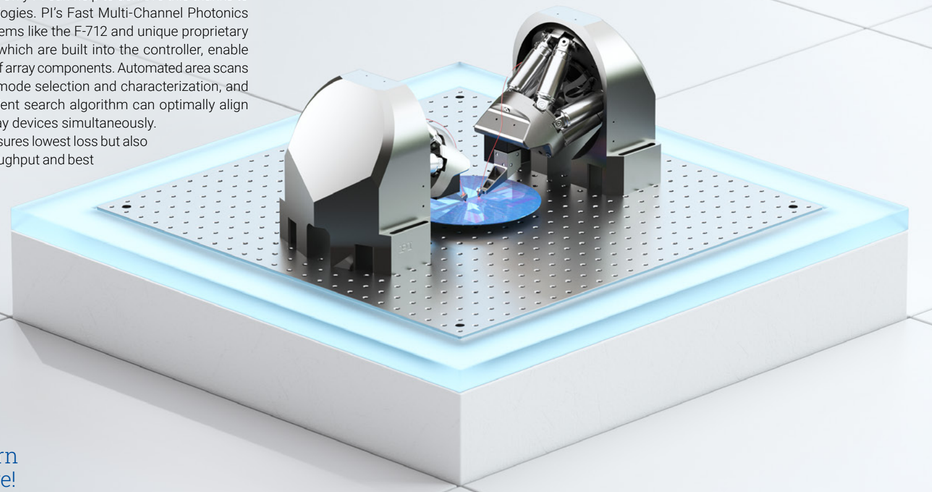
- Piezo Technologies
- Piezo Drive & Positioning Technologies
- Parallel Kinematics & Hexapod Technologies
- Sensor Technologies
- Flexure Joint Technologies
- Magnetic Drive & Levitation Technologies
- Air Bearing Technologies
- Control Strategies & Controllers
- Electronic Circuit Design



Test, Assembly and Packaging of Photonic Devices

Fast Multi-Channel Array Alignment

Photonics today is the driving technology for fields ranging from networking to chiplet packaging to sensor approaches like LIDAR and on to domains like quantum computing. To ensure error-free operation and economic manufacturability, the nanoscale-accurate optical alignment required in each photonic interconnection in each photonic device must be accomplished at scale with high yield, low losses, and speedy timeframes across the multiple channels of array-based devices. Only PI can help to achieve this thanks to industrial-class technologies. PI's Fast Multi-Channel Photonics Alignment (FMPA) systems like the F-712 and unique proprietary alignment algorithms, which are built into the controller, enable fast, parallel alignment of array components. Automated area scans allow fast and reliable mode selection and characterization, and intelligent parallel gradient search algorithm can optimally align and track all I/Os in array devices simultaneously.
Thus, FMPA not only ensures lowest loss but also highest production throughput and best yield.



Learn more!

XYZ Axis: Nanometer Alignment of Optical Components

- Parallel-kinematic piezo system for high stiffness in all spatial orientations
- Mechanical design provides scanning frequencies of up to 100 Hz, as well as fast tracking
- Zero-play flexure guides for high guiding accuracy without any wear or particle generation
- Integrated sensors offer excellent linearity of motion and long-term stability
- Piezo actuators with all-ceramic insulation for an outstanding lifetime

>> P-616 NanoCube® Nanopositioner

>> F-712 Double-Sided Alignment System

XYZ / θX θY θZ: Submicron Alignment of Optical Components

- Parallel-kinematic hexapod for alignment in six degrees of freedom
- High stiffness of the mechanical design provides high dynamics and short settling times
- Freely-definable center of rotation allows flexible alignment
- Position sensors ensure high accuracy and operational reliability
- Compact design for space saving integration

>> H-811 6-Axis Miniature Hexapod

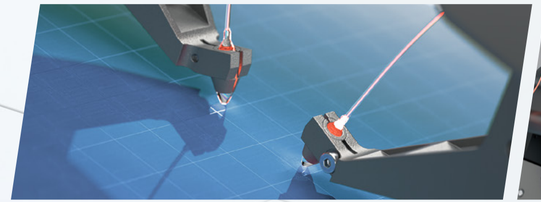
>> F-712 Double-Sided Alignment System

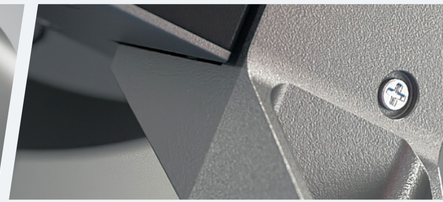
User-Friendly and Flexible Automation Control

- EtherCAT® interfaces for fast integration into high-throughput industrial systems
- High-performance industrial controllers automate built-in scans and optimizations in parallel with millisecond responsiveness
- Proprietary firmware enables fast alignment based on fast area-scanning algorithms for first light detection and gradient search for peak coupling
- Software support for common operating systems, as well as for many programming languages including MATLAB, Python, C#, and NI LabVIEW
- Quick start-up and ease-of-use thanks to PIMicroMove software

>> C-887 Hexapod Motion Controller with EtherCAT®

>> E-712 Digital Piezo Controller



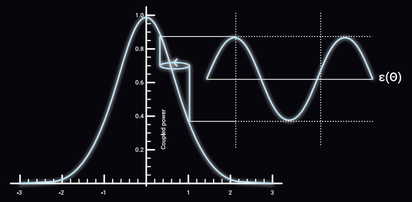


PILightning: Solving the First Light Problem

Revolutionizing Photonics Alignment with Groundbreaking Built-in Functionality

Photonics is at the forefront of innovation and expanding from enabling hyperscale data-center connectivity to consumer applications like LIDAR, wearable health-tech, and new forms of computing. One of the critical challenges in scaling to meet these new demands is the precise alignment of optical components, a task that has traditionally been time-consuming and labor-intensive and repeated multiple times in the test and assembly process. Since this is the top cost driver for photonics device manufacturing, addressing it has been PI's focus since the award-winning Fast Multichannel Photonics Alignment (FMPA) technologies in 2016. By performing optimization in parallel across multiple channels, components, and degrees of freedom and achieving coupling repeatabilities to typically 0.02 dB, FMPA reduces the time and costs for the manufacturing and testing of photonic devices and improves yield.

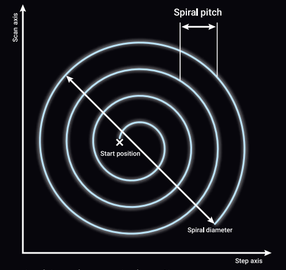
But before the optimization process can even start, an optical signal, above the noise level, needs to be detectable: This process is called first light detection. It is particularly time-consuming in devices with inputs and outputs where both sides must be lined up for even a threshold amount of coupling to be achieved. Finding first light has been a time-consuming procedure in all industrial photonics alignment applications, including wafer probing and device packaging.



Graphical depiction of gradient determination via a circular dither, which modulates the coupled power (or other quantity) observed. The phase of the modulation with respect to the dither indicates the direction towards maximum while its amplitude falls to 0 at optimum.

Traditional First Light Search Algorithms

Historically, first signal finding was based on performing cyclical patterns such as Archimedean spirals or sinusoidal raster scans at the micron-to-submicron scale. In cases of large device-to-device variations or indeterminate fixturing, these repetitive, tightly pitched scans can require significant time to complete depending on the area that must be searched, whether inputs and outputs need to be simultaneously aligned, and so on.



Archimedean spiral routine

PILightning: Finding Photons Faster

Now, a breakthrough has arrived in the form of a novel, built-in search-and-alignment algorithm (patent applied for), promising to revolutionize this field. The algorithm, dubbed PILightning, runs embedded on PI's advanced controllers. It enables highly dynamic mechanics such as piezo scanners or direct-drive air bearing stages to achieve significant economic gains in production over previous first light search algorithms. This new process is fully automated and virtually instantaneous, eliminating the need for extensive calibration or manual intervention. PILightning is based on a new search method with integrated AI-based real-time executive function. It also replaces fine pitch scanning by high frequency data sampling, raising alignment speeds significantly. *It drastically reduces the time required to acquire first-light in single-sided and double-sided couplings and in loopback (omega) waveguide configurations.*

Once first light is detected, the FMPA fast gradient search algorithm takes over, utilizing real-time feedback control to swiftly optimize the alignment in parallel across the degrees of freedom and channels. Depending on the application, a tracking algorithm can also be activated to maintain maximum coupling efficiency—important, for example, in curing situations.

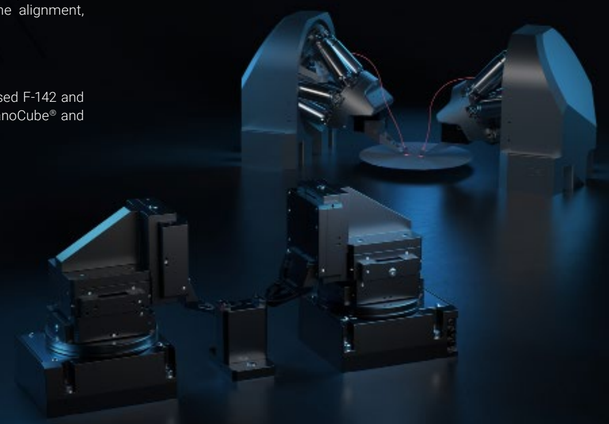
Single-Sided and Double-Sided Alignment

The Greater the Complexity, the More Substantial the Gain

Tests have shown that PILightning reduces first-light capture by typically one order of magnitude or more in single-sided alignment applications. Even higher gains are achieved in double-sided applications. The larger the search area and (as with the FMPA parallel optimization functionality) the more complex the alignment, the more significant the gain.

Who can Benefit?

The new algorithm is immediately available on PI's air bearing-based F-142 and F-143 multi-axis photonics alignment systems and ACS-based NanoCube® and steering mirror controllers.



↗ F-712 double sided hexapod/piezo scanner-based alignment system
↙ F-142, double-sided air bearing-based alignment system

PI

Implications for the Photonics Industry

The Advent of This New Technique Holds Profound Implications for the Photonics Industry

Cost Savings: By drastically reducing alignment times, PI technology enhances the efficiency of photonics manufacturing processes. This leads to reduced production times, lower costs, decreased capex, and increased competitiveness. The reduced need for skilled technicians is another advantage. Companies can allocate their resources more strategically.

Higher Throughput: Faster alignment means higher throughput for manufacturers. This is particularly crucial in high-volume applications such as production wafer probing and device packaging as consumer-market devices must be produced at scale.

New Applications: The improvements in efficiency and reduction of costs open up possibilities for photonics applications in fields where precision alignment was previously a limiting factor. In particular, the quest for passive alignment approaches becomes less urgent.

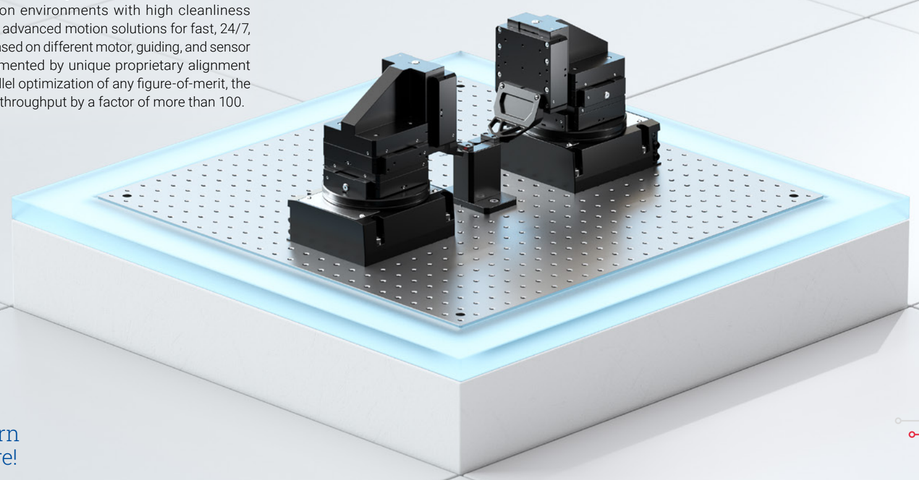
Research Advancements: In research and development, PI alignment technologies' speed allows for quicker testing and prototyping of optical components and systems, accelerating progress in photonics innovations.

Learn more!

Production-Level Wafer Probing and Silicon Photonics Testing

Active Alignment at High Duty Cycles

Silicon photonics plays a crucial role in the advancement of cutting-edge technologies such as quantum computing, nanosatellites, light detection and ranging (LIDAR), or optical logic, as well as in improving data processing, storage, and transmission. These technologies place many challenges on test and packaging processes, especially when it comes to the alignment of fiber optic devices in high-volume production environments with high cleanliness requirements. PI offers advanced motion solutions for fast, 24/7, automated operation based on different motor, guiding, and sensor technologies. Complemented by unique proprietary alignment algorithms for the parallel optimization of any figure-of-merit, the solutions can increase throughput by a factor of more than 100.



Learn more!

DRIVEN BY ACS MOTION CONTROL
PART OF THE PI GROUP

θZ Axis: Precise Rotational Positioning of Photonic Devices

- Highly accurate and repeatable 360° rotation without backlash
- Direct drive motor technology enables smooth and precise operation without cogging
- Brushless torque motor for high dynamics
- High-precision absolute or incremental encoder options
- Low-profile design for space-saving integration

>> V-623 High-Precision Rotation Stage with Direct Drive

User-Friendly and Flexible Automation Control

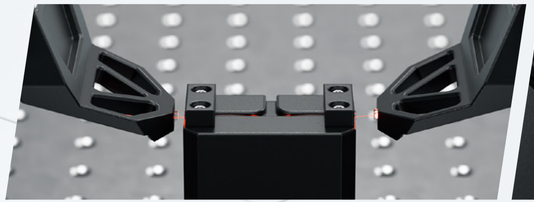
- High-performance industrial controller with onboard ACS-based alignment algorithms
- Proprietary firmware provides fast area-scanning algorithms for first light detection, as well as gradient and centroid algorithms for peak coupling.
- Software support for common operating systems, as well as for many programming languages including MATLAB, Python, C#, and NI LabVIEW

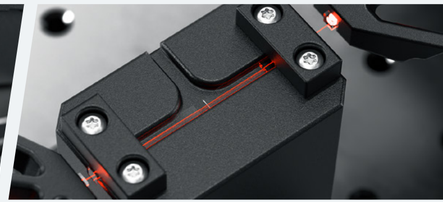
>> A-81x PIglide Motion Controller

XYZ Axis: Fiber-to-Fiber or Fiber-to-Waveguide Alignments

- Friction-free and maintenance-free air-bearing design for 24/7 high duty cycle applications
- Voice coil direct drive motor for smooth operation, high dynamics and fast step-and-settle
- Integrated linear encoders for accurate positioning
- Innovative and compact XYZ design for space-saving integration
- Integrated Z-axis counterbalance enables vertical operation with minimal impact on stage's form factor

>> A-142 PIglide Voice Coil Linear Stage with Air Bearings

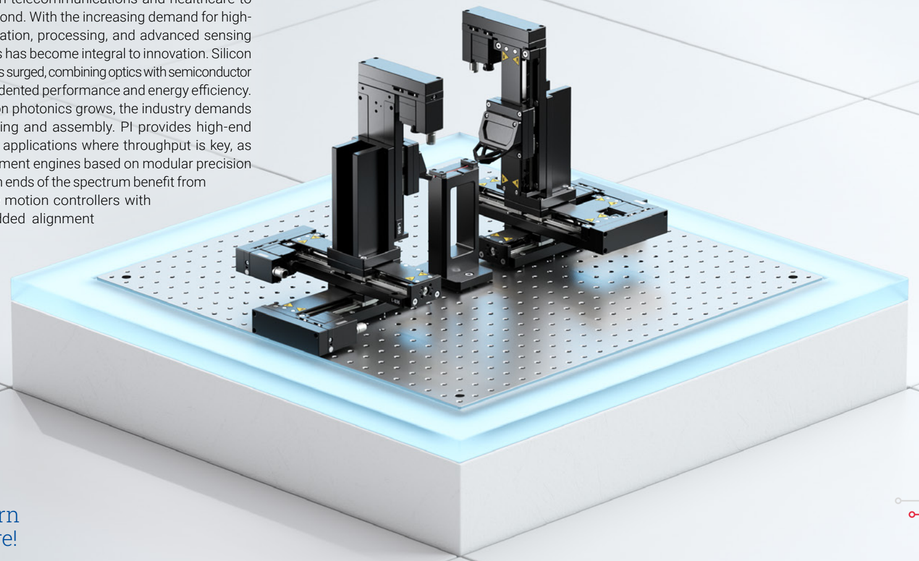




Alignment of Optical Fibers and Photonic Devices

Cost-Effective Alignment Solutions

Photonics, the science and application of light, has transformed industries ranging from telecommunications and healthcare to manufacturing and beyond. With the increasing demand for high-speed data communication, processing, and advanced sensing technologies, photonics has become integral to innovation. Silicon photonics, in particular, has surged, combining optics with semiconductor technology for unprecedented performance and energy efficiency. As the global reliance on photonics grows, the industry demands new solutions for testing and assembly. PI provides high-end alignment systems for applications where throughput is key, as well as affordable alignment engines based on modular precision positioning stages. Both ends of the spectrum benefit from PI's high-performance motion controllers with award-winning embedded alignment algorithms.



Learn more!

XYZ Axis: Precision Linear Stages

- Low profile, compact, high-stiffness mechanical design
- Travel range to 200 mm
- Precision ball screw and recirculating ball bearing guides
- Direct-drive stepper motors, 40 mm/s max. velocity
- Linear encoder option for higher accuracy and repeatability
- Holding brake option prevents collision
- Economically priced with fast delivery

>> L-836 Universal Linear Stage

Optional Rotary Stages

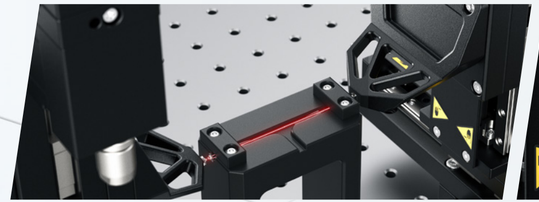
- Highly accurate and repeatable rotation
- Choice of direct-drive and worm-gear designs
- Closed-loop option for higher accuracy and repeatability

>> Rotary Stages

High Performance Motion Controller

- EtherCAT® controller for open network connectivity
- Embedded high-performance alignment algorithms for fast and reliable alignment

>> Motion Controller



S-331 Fast Piezo Steering Mirror Platform

- Tip/tilt angle up to 5 mrad, optical deflection angle up to 10 mrad (0.57°)
- Differential drive for increased stability
- Two orthogonal tip/tilt axes with common center of rotation
- High resonant frequencies to 10 kHz (0.5" mirror) for dynamic motion and fast step-and-settle
- Parallel kinematics design provides identical high dynamics of both axes
- Ultra-compact design
- Durable and friction free thanks to flexures
- Closed-loop sensors for high linearity
- For mirrors up to Ø 12.7 mm (0.5")

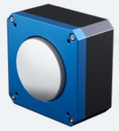
>> S-331 High-Speed Tip/Tilt Platform

The S-331.2 standard piezo tip/tilt platform has been tested to survive a launch and operate in LEO applications. It provides up to 4 mrad tip/tilt motion and 0.05 µrad resolution, and an unloaded resonant frequency of 10 kHz

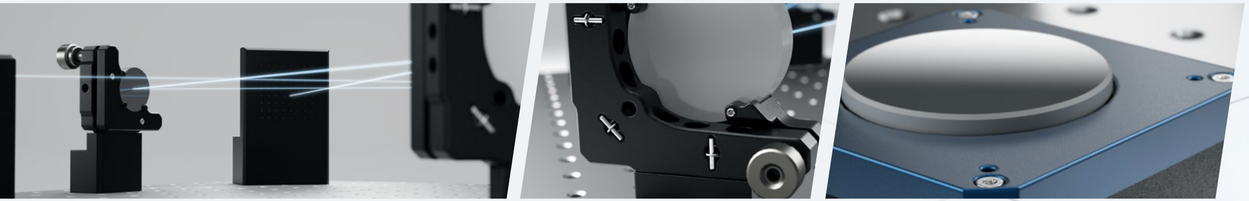
V-931 Fast Voice Coil Steering Mirror Platform

- Tip/tilt angle up to 4° , optical deflection angle up to 8°
- Differential drive for increased stability
- Two orthogonal tip/tilt axes with common center of rotation
- Parallel kinematics design provides identical high dynamics of both axes
- Compact design
- Durable and friction free thanks to flexures
- Optical encoders for high precision closed-loop operation
- Custom designs for space applications

>> V-931 High Dynamics PIMag® Voice Coil Tip/Tilt Platform



The V-931 voice coil tip/tilt platform provides up to four degrees of tip/tilt motion and 1 µrad minimum incremental motion. It can settle in as little as 20 ms. This voice coil steering mirror platform can be customized for space applications



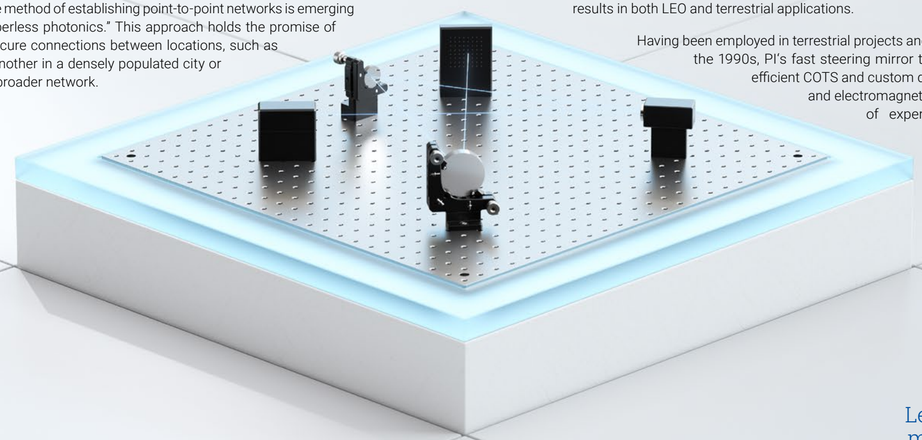
Free Space Optical Communication Enabled by Fast Steering Mirrors

Proven Solutions for Laser Beam Control on Earth and in Space

Today, the backbone of the global network relies on fiber optic cables connecting everything on our planet—from individual people to datacenters and machines. Recently, a new race for a different data and telecommunication network infrastructure has been unfolding. Several technology companies are working on deploying extensive low earth orbit (LEO) space-based communication networks, with compact satellites as their nodes. Thousands of these satellites will be launched into orbit, utilizing laser light to connect to each other, and efficiently transmit data across the globe. On earth, a comparable method of establishing point-to-point networks is emerging through the use of "fiberless photonics." This approach holds the promise of rapidly establishing secure connections between locations, such as from one building to another in a densely populated city or for the "last mile" of a broader network.

Launch-qualified piezoelectric or electromagnetic Fast Steering Mirrors (FSM) from PI provide resolution down to the nanorad range with mechanical bandwidth reaching up to the kHz range. These mirrors, whether piezoelectric (higher resolution and bandwidth) or voice coil (larger displacement), effectively compensate for common disturbances and drift in various applications. With its track-record in providing mission-critical tracking performance and stability, PI has shipped large quantities of standardized designs and application specific configurations with exceptional results in both LEO and terrestrial applications.

Having been employed in terrestrial projects and space missions since the 1990s, PI's fast steering mirror technology showcases efficient COTS and custom designs, based on piezo and electromagnetic drives. With a wealth of experience and advanced production equipment, PI is in a position to scale rapidly.

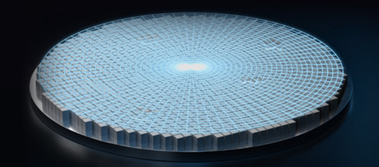


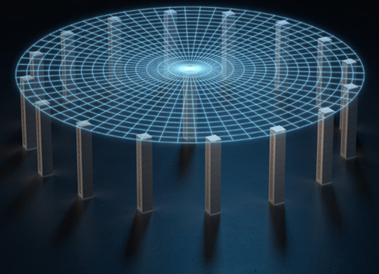
Learn more!

Achieve Maximum Accuracy and Control in Surface Shaping

Hybrid Actuator Technologies for High-Precision Applications

The future of surface shaping is here. As an experienced player in the semiconductor industry, PI is continuously developing new solutions for maximum precision and control, even at high resolution and the smallest structure sizes. The latest developments in surface processing range from dynamic shaping of surfaces to correction of static changes, complemented by outstanding functionality.
Hybrid solutions combining patented technologies and precision components form the basis for advanced positioning systems. The use of active and semi-active actuator elements and intelligent actuator arrays enables high-precision surface shaping with maximum control. Dynamic, quasi-static, and combined drives provide a wide range of amplitudes with minimized position noise. Static changes caused by tolerances, wear, or drift, for example, are corrected without a permanent power supply.
Surface shaping solutions from PI are available for a wide range of high-precision applications. These solutions are based on intelligent control and sensor technology, enabling precision in the nanometer and subnanometer range, as well as deformations in the micrometer range. ((1.157))

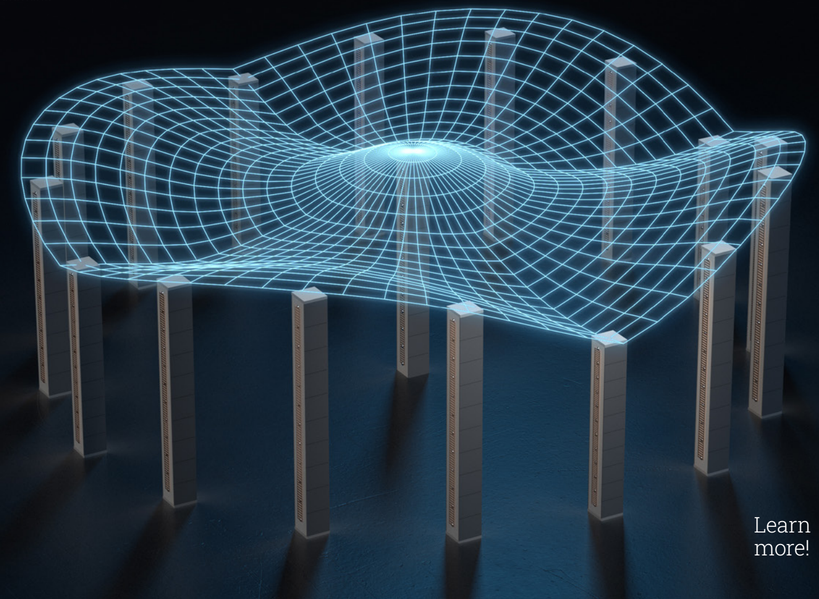




↗ The use of piezoceramic material with a structured composition enables the highest operational flexibility and the shaping of the smallest features.
→ The combination of dynamic, quasi-static, and mixed operation allows the generation of different amplitudes with minimized position noise

Flexible in Shape

Variable arrangement of actuators or actuator arrays will enable multiple types of deformation with the highest resolution. Smart wiring, drive, and sensor concepts can simplify the hardware environment.

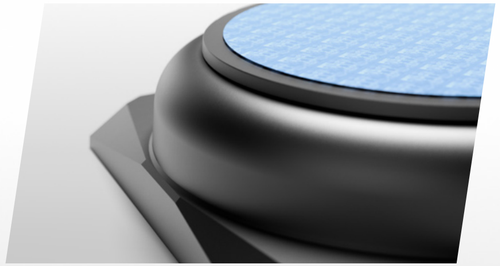


Learn more!

Wafer Inspection and Metrology

Highly Dynamic and Precise Piezo Wafer Positioning Solution

Efficient wafer inspection and metrology are key success factors in semiconductor manufacturing. In addition, they are becoming more demanding, challenging, and costly as feature sizes shrink and design complexity increases. Metrology processes are therefore highly dependent on precise wafer positioning to enable the fast and reliable analysis of defects or particles at each step of the manufacturing process to prevent yield loss.



Multiple degrees of freedom

ith the development of an innovative hybrid kinematics configuration, PI expands the system options for wafer platforms with four independent degrees of freedom: Tip, Tilt, Z and rotation around Z. Loading and unloading is performed by an integrated wafer lift. The hybrid kinematics configuration features unique piezo actuators for high-precision Z-axis motion. These provide fast step-and-settle over long travel ranges as well as real-time dynamic motion over small areas.
Adopters of the new technology are streamlining their design processes and achieving greater precision and reliability. At the same time, they are able to minimize equipment complexity and integration efforts, thereby reducing costs and risks.

Next-generation standards

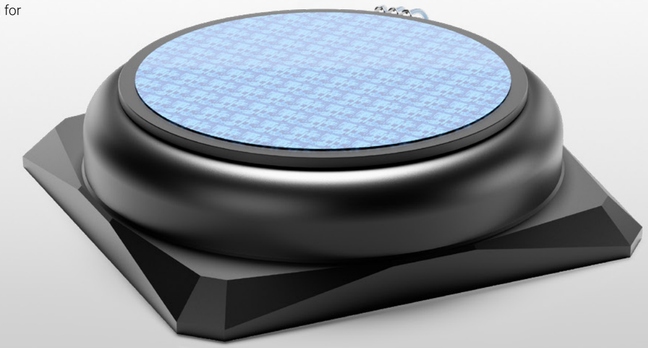
- Wafer motion profiles for advanced semiconductor metrology applications, as Surface profiling, BF/DF optical defect inspection and Edge Placement Error (EPE) metrology.
- Highest accuracy, dynamics, and crosstalk suppression
- Compact design due to high integration level
- Breakthrough control capabilities
- Unparalleled precision and reliability
- Easy connectivity
- Feedback functions to eliminate hysteresis and optionally provide absolute positioning reliability with a picometer resolution, safeguarding machines, components, and tools.
- A standard solution for OEMs, customizable to meet specific criteria.

Dynamic operation

The new development from PI offers significant advantages over electromagnetic concepts. With native support for wafer fiducial alignment, before positioning/ moving the wafer, the module first corrects the rotational misalignment of the wafer and holds the wafer in the correct position under the tool. Wafer thickness and machine static characteristics are taken into account.

Once the process is complete, the actuators can be turned off and held in position so that no more energy is needed, and therefore, no heat is generated in the wafer area that could affect precision. This eliminates the need for additional cooling or balancing.

The secondary mode of the piezo actuators is used to locate and track the focus. The analog element mode allows for highly dynamic operation, compensating for flatness and angular errors and ensuring that the focus is maintained.

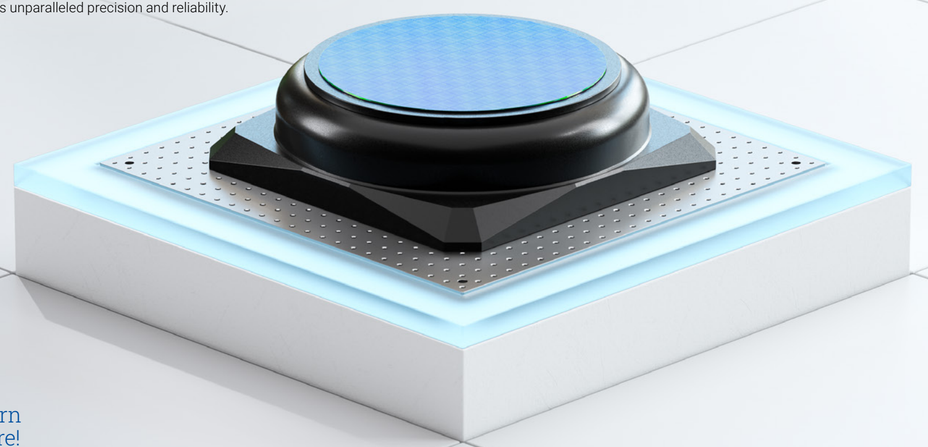


Highly Dynamic and Precise Piezo Wafer Positioning Solution

Fast Step-and-Settle and Real-Time Dynamic

PI offers proven wafer scanning subsystems that take advantage of piezo technology to meet demanding process requirements where conventional electromagnetic solutions reach their limits.

PI's innovative piezo wafer positioning solution features an innovative design, groundbreaking control capabilities and easy connectivity. The combination of a dual-function piezo actuator, hybrid kinematics mechanism, and next-generation motion controller offers unparalleled precision and reliability.



Learn more!

Z Axis: Dynamic Tracking

- Piezo motor technology
- Power off holding ability
- High resonant frequency enables highly dynamic tracking and correction mode for fine motion.
- Travel range: up to 4 mm coarse and 50 µm fine
- Move and settling time <10 ms (0.01 µm - 50 µm)
- Bidirectional repeatability: 10 nm (1 sigma)
- Position stability < 5 nm

Z-Rotation Axis: High-Accuracy Motion up to 360°

- Piezo motor technology
- High resonance frequency for highest stability
- Travel range: up to +/-6 mrad for highest accuracy, can be extended to up to 360°
- Move and settling time < 20 ms (0.1 µrad - 100 µrad)
- Bidirectional repeatability: 0.5 µrad (1 sigma)
- Position stability < 0.05 µrad

Tip/Tilt Axis: High Stability

- High resonance frequency for highest stability
- Travel range: up to +/-6 mrad for highest accuracy, can be extended to up to 360°
- Move and settling time < 20 ms (0.1 µrad - 100 µrad)
- Bidirectional repeatability: 0.5 µrad (1 sigma)
- Position stability < 0.05 µrad

Liftpin Function: Integrated Wafer Lift

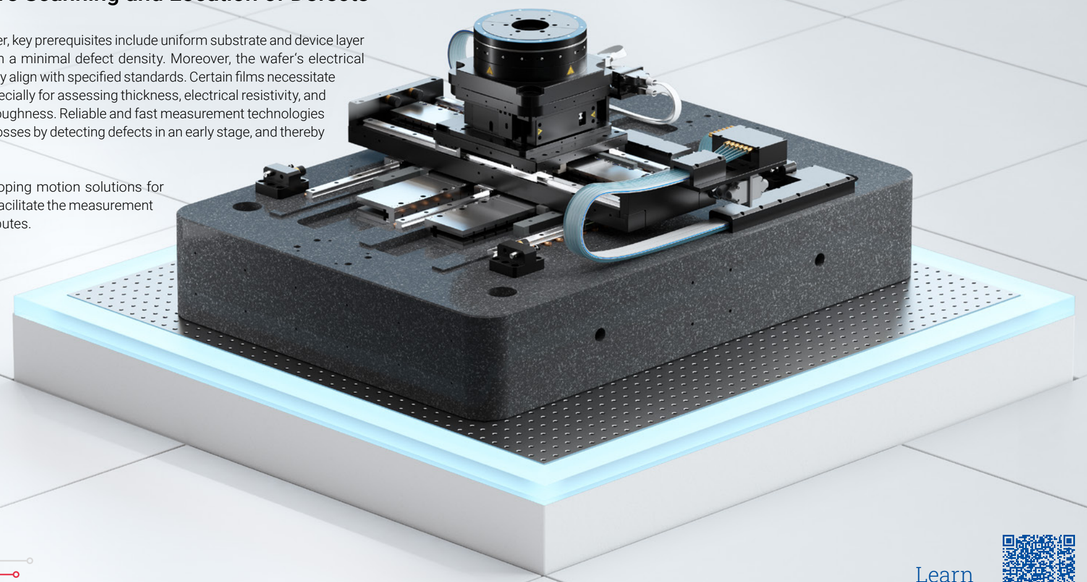
- DC motor driven spindle
- Travel range > 10 mm
- Velocity: up to 20 mm/s
- Bidirectional repeatability <1 µm (1 sigma)

Wafer and Substrate Inspection and Metrology: Granite-Based Motion Systems

Cost-Effective Scanning and Location of Defects

For every type of wafer, key prerequisites include uniform substrate and device layer thickness, along with a minimal defect density. Moreover, the wafer's electrical resistivity must closely align with specified standards. Certain films necessitate characterization, especially for assessing thickness, electrical resistivity, and surface quality and roughness. Reliable and fast measurement technologies help to prevent yield losses by detecting defects in an early stage, and thereby reducing costs.

PI is currently developing motion solutions for wafer positioning to facilitate the measurement of crucial wafer attributes.



θZ Axis: Fine Rotary Indexing and Alignment of Wafer or Substrate

- Highly accurate and repeatable 360° rotation without backlash
- High velocities and accelerations due to magnetic direct drives
- Direct-drive, slotless, brushless torque motor offers very low cogging torques and enables smooth speed and low error motions
- Ultra-precise air bearings developed and manufactured in house
- Next level performance to further optimize asynchronous performance specifications

>> Technology of Direct Drive Torque Motors

Z Axis: Precision Wafer Alignment

- Low profile, high load, compact superior design
- Direct drive voice coil technology provides zero cogging, smooth motion with nanometer step size and response
- High-resolution encoder for nanometer positioning of the motion platform
- High-precision anti-creep crossed-roller bearings
- Pneumatic counter balance prevent motor heating and prevents collisions
- Economically priced with fast delivery

>> Technology of Direct Drive Motors

XY Axis: Precision Step and Settle Motion

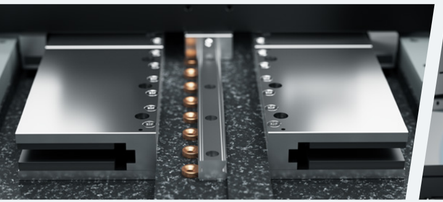
- High-dynamics, coupled ironless linear motors on base axes for powerful, fast and precise motion
- Dual encoder system ensures motor and yaw alignment, whilst provided high resolution and accuracy
- Multiple bearing stiff platform with low profile reduces abbe offsets and offers increased flatness and straightness
- Design allows high flexibility and customization
- Optimized integrated cable management reduces motion drag and prolongs lifetime
- Granite base ensures highest performance of the motion system
- Optional active isolation

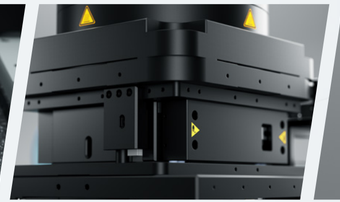
>> Direct Drive Linear Motor Stages

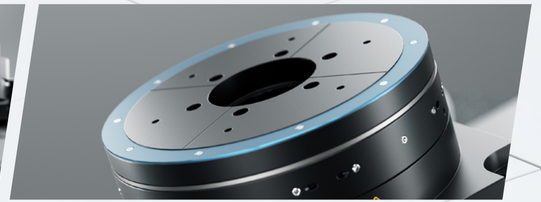
Flexible and Easy Automation Control

- EtherCAT® controller for open network connectivity
- Advanced algorithms provide fast step-and-settling, high in-position stability, and exceptional constant scanning velocity
  >> ServoBoost™
- Autofocus capabilities of the controller for dynamic focus adjustment
- Look-ahead capability adjusts velocity to maintain accuracy

>> Motion Controller







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Wafer Inspection and Metrology: Supported by Air Bearings

Rapid Scanning and Characterization at the Wafer Level

The chip manufacturing process involves 400 to 800 production steps, with critical inspection processes at various stages to ensure high quality and reliability. These inspections are crucial not only for maintaining product integrity but also for securing a defined yield in the cost-intensive chip production. As technology advances, the inspection process becomes more complex and costly, with decreasing defect tolerance due to process shrinks, smaller features, design intricacies, and the integration of heterogeneous components at the wafer level. Modern optical inspection tools must address these challenges by detecting defects in the nanometer range, allowing the removal of damaged structures early in the process to reduce costs. These tools often operate in scanning modes, identifying specific positions first and approaching them with high precision subsequently, or follow predefined trajectories for processing steps.

Learn more!

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Z Axis: High-Dynamic Laser Focus Control

- Wear-free, lever-amplified piezo drives for 24/7 operations without particle generation
- Piezo-mechanical design provides high stiffness and force for fast response and short settling times, ideal for moving heavy, high-performance objectives
- Up to 800 µm travel range
- Fine positioning with subnanometer resolution

>> P-725 PIFOC® Objective Scanner

θX/θY/Z Axis: High-Precision Wafer Alignment and Positioning

- Parallel-kinematic Z-tip-tilt design for wafer adjustment and offset corrections in three dimensions
- Non-contact linear motors and air bearings provide high geometric accuracy
- Frictionless design provides high repeatability with resolution in the nanometer range
- Low-profile design for easy integration
- Wear-free and maintenance-free design for 24/7 operations

>> A-523 Z Tip/Tilt Stage

XY Axis: Wafer Step-and-Scan Motion

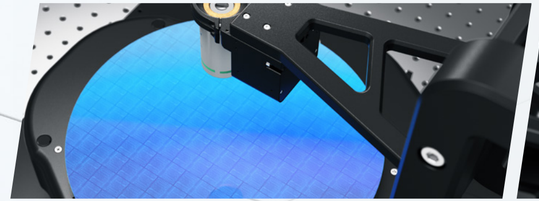
- Air-bearing planar scanner with ironless linear motors for high, cog-free scanning speed and fast stepping and settling times
- Contact and wear-free design allows 24/7 high duty cycle operations with minimal runout errors and nanometer straightness and flatness
- High-resolution absolute linear encoder option for fast startup, reliability, and safety
- Low profile monolithic design allows easy integration to system level solutions for compact installation space
- Wide carriage provides increased stiffness

>> A-311 Air Bearing Planar Scanner

Advanced Automation Control

- EtherCAT® motion control and drive modules provide open network connectivity
- Advanced algorithms provide fast step-and-settling, high in-position stability, and exceptional constant scanning velocity
- ServoBoost™
- Fast digital interchange to trigger fast focus on Z axis

>> Motion Controller

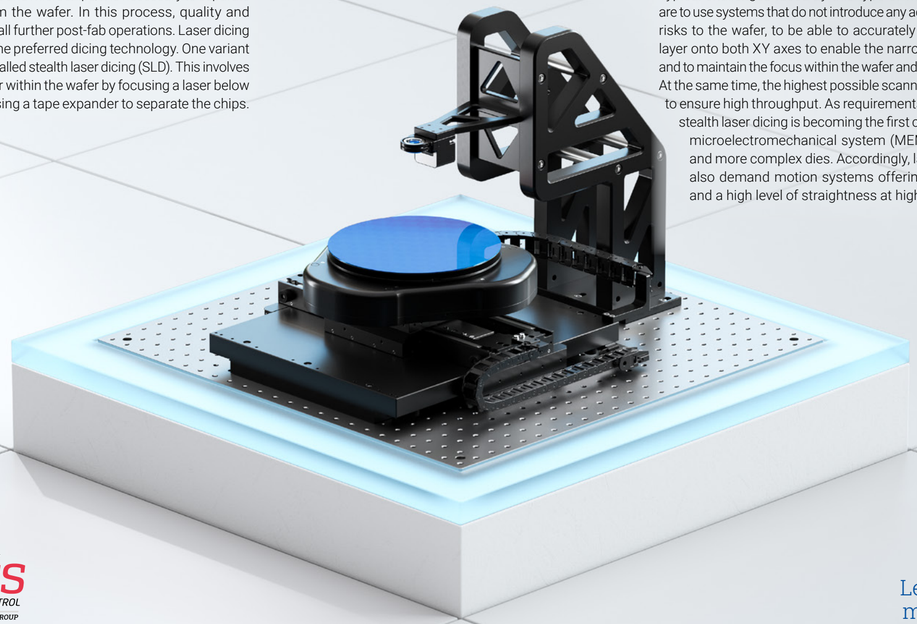


Wafer Stealth Dicing

Accurate Formation of the Modified Layer

In the production of chips and microchips, it is necessary to separate the individual dies from the wafer. In this process, quality and precision are crucial for all further post-fab operations. Laser dicing has therefore become the preferred dicing technology. One variant of laser dicing is the so-called stealth laser dicing (SLD). This involves creating a modified layer within the wafer by focusing a laser below the surface, and then using a tape expander to separate the chips.

Typical challenges faced by this type of wafer dicing application are to use systems that do not introduce any additional contamination risks to the wafer, to be able to accurately position the modified layer onto both XY axes to enable the narrowest possible streets, and to maintain the focus within the wafer and track wafer distortions. At the same time, the highest possible scanning speed is necessary to ensure high throughput. As requirements continue to increase, stealth laser dicing is becoming the first choice for high-volume, microelectromechanical system (MEMS) dicing, or smaller and more complex dies. Accordingly, laser-dicing processes also demand motion systems offering both high accuracy and a high level of straightness at high velocities.



Z Axis: High-Dynamic Laser Focus Control

- Wear-free, lever-amplified piezo drives for 24/7 operations without particle generation
- Mechanical design with high stiffness and high resonant frequencies for high dynamics and short settling times and for high payload of larger objectives
- Up to 800 µm travel range to match the wafer thickness
- Fine positioning with subnanometer resolution

>> P-725 PIFOC® Objective Scanner

XY Axis: High-Dynamic Wafer Scanning Motion

- Air-bearing planar scanner with ironless linear motors for high, cog-free scanning speed and fast stepping and settling times
- Contact and wear-free design allows 24/7 high duty cycle operations with minimal runout errors and nanometer straightness and flatness
- High-resolution absolute linear encoder option for fast startup, reliability, and safety
- Low profile, monolithic design allows easy integration to system level solutions for compact installation space
- Wide carriage insures increased stiffness

>> A-311 Air Bearing Planar Scanner

θX/θY/Z Axis: High-Precision Wafer Alignment and Positioning

- Parallel-kinematic design for wafer adjustment and offset corrections in three dimensions
- Direct drive linear motor with air bearings for high-precision levelling
- Frictionless design with minimal hysteresis provides high repeatability and adjustments in the nanometer range
- Low-profile design for easy integration
- Maintenance-free with long lifetime in 24/7 operations

>> A-523 Z Tip/Tilt Stage

Advanced Automation Control

- EtherCAT® motion control and drive modules provide open network connectivity
- Laser control interface synchronizes the fixed laser beam to the motion path for high-accuracy cutting
- Advanced algorithms like ServoBoost™ provide fast step-and-settling, high in-position stability, and exceptional constant scanning velocity
  >> ServoBoost™
- NanoPWM™ drive technology reduces tracking error and optimizes velocity
- Integrated piezo height axes control synchronized to wafer scan axes

>> Motion Controller

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Beam Management / Beam Stabilization / Beam Correction

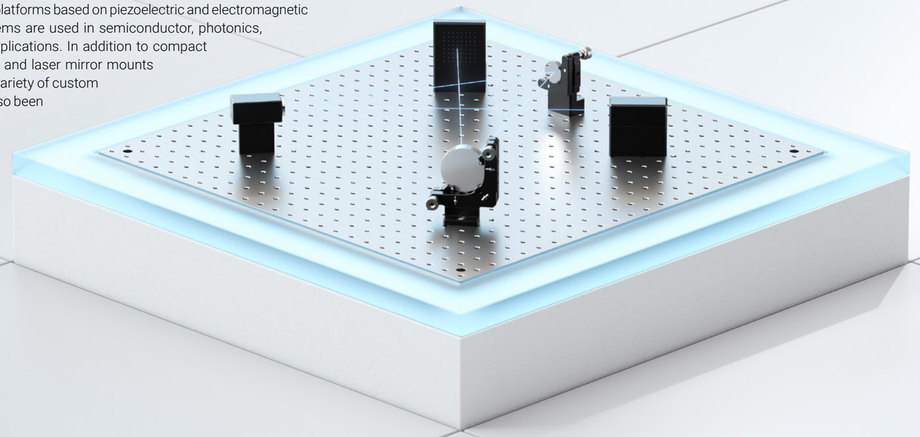
High Resolution Beam Steering Systems

Beam management is critical in many semiconductor-related manufacturing and inspection technologies. For example, in the metrology process of wafer production, the path of the light or laser beam must be precisely and continuously adjusted. This adjustment is crucial for monitoring the wafer surface, detecting imperfections, and providing detailed information about the wafer quality.

PI has more than 40 years of experience in designing ultra-precise fast beam steering (FSM) and image stabilization platforms based on piezoelectric and electromagnetic drive technologies. Our systems are used in semiconductor, photonics, aerospace, and astronomy applications. In addition to compact COTS beam steering systems and laser mirror mounts with nanoradian resolution, a variety of custom systems for large optics has also been designed by our nanopositioning and motion control experts.

Fast Focus and Active Wafer Shaping

In addition to active optics, high-resolution fast focus drives are available for surface metrology applications. Our new multi-actuator matrix designs can form the basis for active optics and active wafer shaping with sub-nanometer precision.



Learn more!

Fast Piezo Steering Mirror Platform

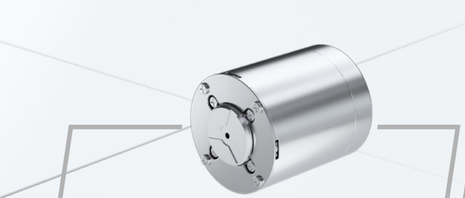
- Tip/tilt angle up to 5 mrad, optical deflection angle up to 10 mrad
- Differential drive for increased stability
- Two orthogonal tip/tilt axes with common center of rotation
- High resonant frequencies to 10 kHz (0.5" mirror) for dynamic motion and fast step-and-settle
- Parallel kinematics design provides identical high dynamics of both axes
- Ultra-compact design
- Durable and friction free thanks to flexures
- Sensors for high linearity in closed-loop operation
- For mirrors up to Ø 12.7 mm (0.5")
- Mars-rover tested PICMA® piezo actuators and flexure guides

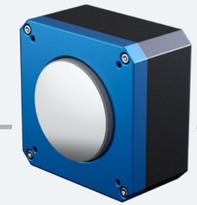
>> S-331 High-Speed Tip/Tilt Platform

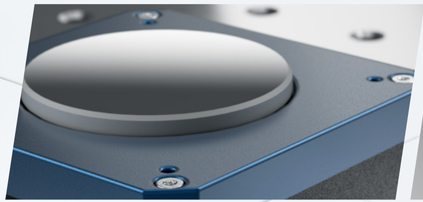
Fast Voice Coil Steering Mirror Platform

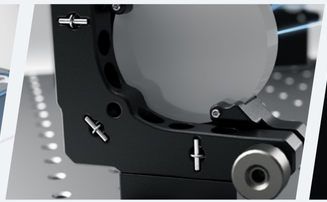
- Tip/tilt angle up to 4°, optical deflection angle up to 8°
- Differential drive for increased stability
- Two orthogonal tip/tilt axes with common center of rotation
- Parallel kinematics design provides identical high dynamics of both axes
- Compact design
- Durable and friction free thanks to flexures
- Optical encoders for high precision closed-loop operation
- Custom designs for space applications

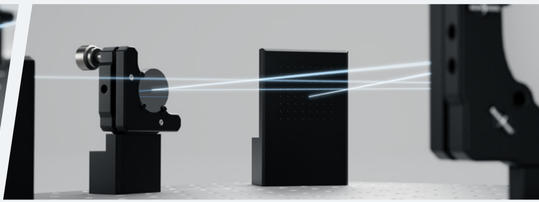
>> V-931 High Dynamics PIMag® Voice Coil Tip/Tilt Platform







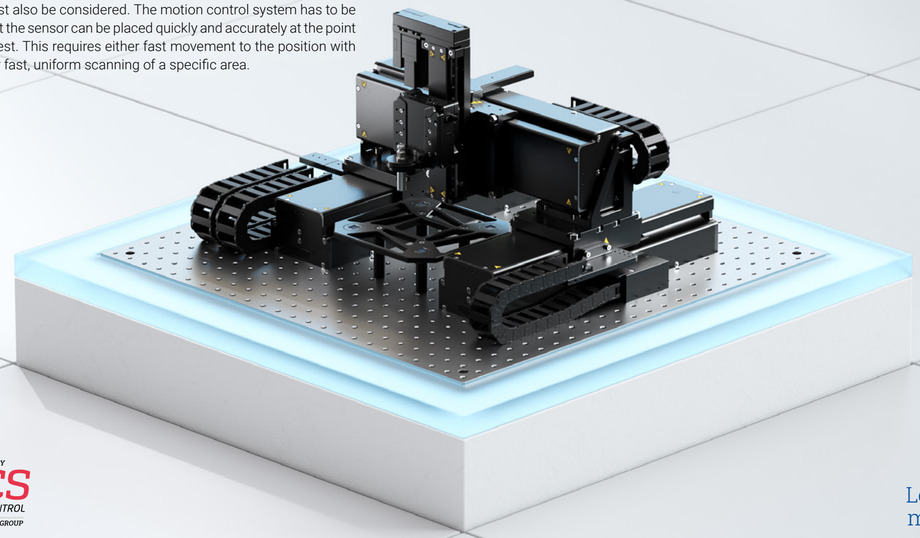




3D Profiling of Small Components and Features

Fast and Reliable Sensor Placement and Scanning

Fast and reliable measurement of the surface profile of smallest components and features places high demands on the motion and control systems as well as on the sensor technology: End products must meet the requirements regarding functionality and quality. The sensor technology used should be chosen based on criteria such as sensor resolution, measuring range, and speed of data acquisition. In case of a laser-based sensor, the size of the focal spot, measurement field, or view area and the ability to focus must also be considered. The motion control system has to be configured in a way that the sensor can be placed quickly and accurately at the point or in the areas of interest. This requires either fast movement to the position with a short settling time or fast, uniform scanning of a specific area.



XY Axis: Fast Step-and-Scan Motion of the Sensor

- Ironless linear motors for high-dynamic, precise, and smooth motion for fast step-and-scan
- Absolute encoders avoid referencing and ensure operational safety
- XY drag chain cable management maintains cable integrity and prolongs lifetime

>> V-855 High-Speed Linear Stage

Z Axis: Precise Vertical Motion of the Sensor

- High-precision ball screw linear stage with stepper motor and holding brake for reliable operation with simple and extremely stable positioning
- Folded drivetrain and compact design reduces installation space
- Low-weight design to maintain gantry dynamics

>> L-836 Stackable and Highly Compact Linear Stage

Z Axis: Sensor Focusing for Distance Control

- Voice coil direct drive motor for friction-free operation, high scan frequencies, and fast step-and-settle
- High-resolution linear encoders for accurate position feedback
- Adjustable weight force compensation for safe operation
- Easy integration thanks to flexible mounting options

>> V-308 Voice Coil PIFOC® Focus Drive

Measuring Surface Depths

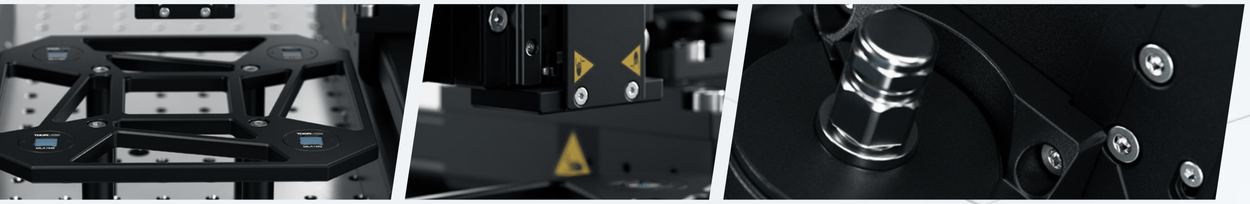
- Spot size down to 2 µm enables tiny features to be measured, as well as extremely precise positioning
- Wide range of working distances
- High resolution at fast speeds for dynamic autofocus compensation and high throughput

>> Optical Distance Sensor

Advanced Automation Control

- EtherCAT® motion control and drive modules provide open network connectivity
- Conversion of sensor output to position data for fast output via analogue or digital interfaces
- Extensive motion controller algorithms for fast motion and settle, as well as smooth scanning
- Autofocus capabilities for dynamic focus adjustment

>> Motion Controller



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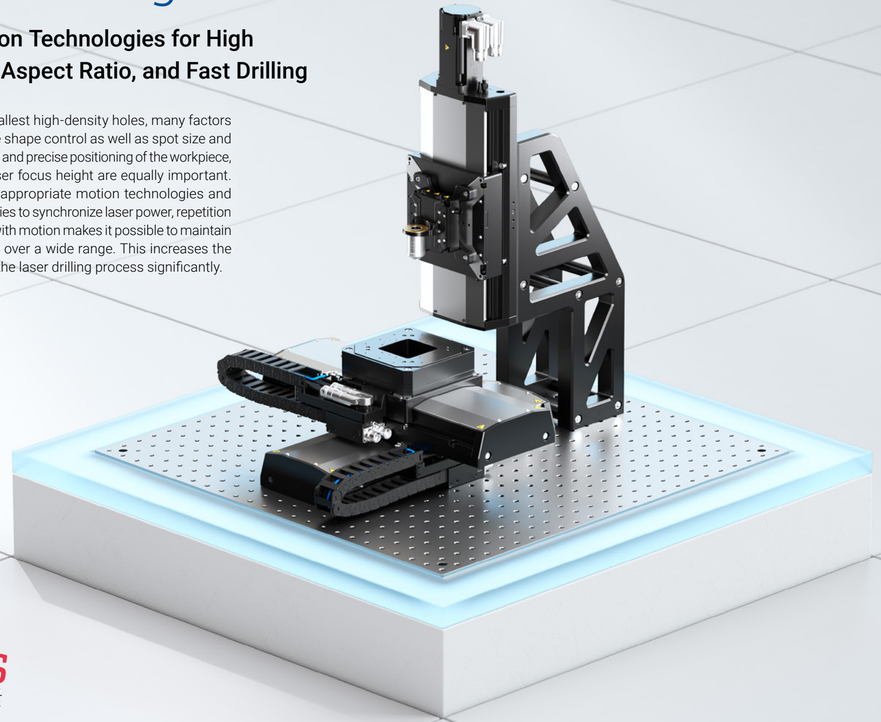
Laser Drilling of Micro Holes

Combined Motion Technologies for High Precision, High Aspect Ratio, and Fast Drilling

When laser drilling the smallest high-density holes, many factors will impact the result: cone shape control as well as spot size and wavelength of the laser. Fast and precise positioning of the workpiece, the laser head, and the laser focus height are equally important. The right combination of appropriate motion technologies and user-friendly control strategies to synchronize laser power, repetition rates, and laser frequency with motion makes it possible to maintain hole accuracy and density over a wide range. This increases the throughput and quality of the laser drilling process significantly.



Z Axis: Reliable Laser Height Control

- High-precision ball screw linear stage with servo motor and holding brake for safe and reliable operation under high loads
- Absolute encoders to avoid collisions
- Robust industrial IP65 connectors for flexible cable exits
- Side seal and hard cover to protect from particles

>> L-417 High-Load Linear Stage

XY Axis: Fine Positioning of the Workpiece

- Piezo-based XY scanner for highly-dynamic positioning with nanometer precision
- Parallel-kinematic design for equal dynamics in X- and Y-directions
- High guiding accuracy thanks to zero-play flexure guides
- Subnanometer resolution with long-term stability
- High tracking accuracy in the nanometer range

>> P-527 Multi-Axis Piezo Scanner

Z Axis: Dynamic Laser Focusing for Taper Control

- Voice coil direct drive motor for friction-free operation and high scan frequencies
- Fast step-and-settle
- Integrated linear encoders for accurate position feedback
- Adjustable weight force compensation for safe operation

>> V-308 Voice Coil PIFOC® Focus Drive

XY Axis: Workpiece Positioning Over Extended Travel Ranges

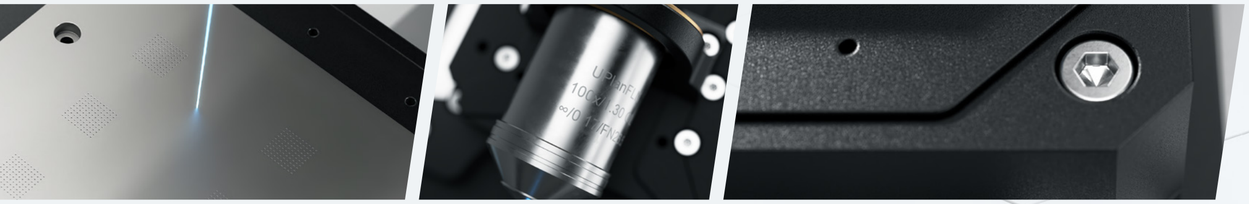
- Highly-dynamic ironless linear motors for fast and precise contouring
- Reference edge for easing alignment in the machine
- Connector for purge air, plus side seal, and hard cover to protect against particles
- Absolute encoders avoid referencing and ensure safety during operation

>> V-417 High-Load Linear Stage

Flexible and Easy Automation Control

- Profile generation via EtherCAT® or triggering of predefined drilling profiles
- Intuitive browser-based software for system operation
- Laser pulse control via EtherCAT® or analog power output
- Servo control for fast step-and-settle and for disturbance rejection
- Option of adding fast piezo control for improved performance

>> E-712 Digital Piezo Controller



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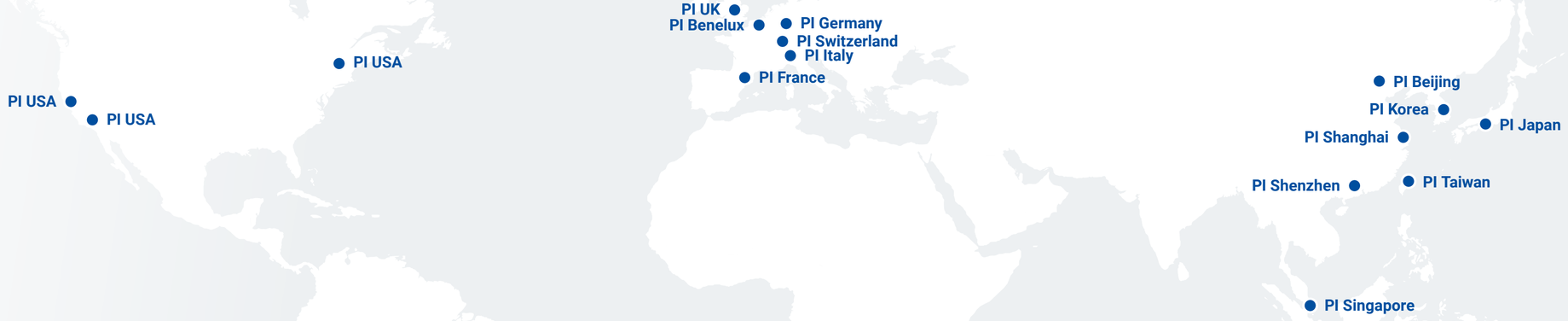
About Physik Instrumente (PI)

Physik Instrumente (PI) with headquarters in Karlsruhe, Germany, is market leader for high-precision positioning solutions and piezo technology applications in the market segments of Industrial Automation, Photonics, Semiconductor, and Microscopy & Life Sciences. In close cooperation with international customers, PI has been pushing technological boundaries and developing solutions to drive future market trends for more than fifty years. More than 500 patents prove the company's claim to innovation. PI develops, manufactures, and qualifies its entire core technologies: from piezo elements and motors, magnetic direct drives and air bearings, and magnetic and flexure guides to sensors, as well as controllers and software. With nine production sites and sixteen sales and service offices in Europe, North America, and Asia, the PI Group is ideally positioned in all key technology regions. The privately owned company is experiencing healthy growth and employs more than 1,500 employees worldwide.



Innovation drives the world. **We drive innovation.**

High-Precision Motion and Control Solutions for Your Applications

Turning ideas into advanced motion solutions that enable our customers to improve their applications and shape future markets is what drives us at PI. Thanks to our in-depth expertise in piezo technology, nano positioning, and performance automation—combined with a wide range of technologies and a high level of vertical integration—we can meet the specific requirements of a variety of applications. Our solutions range from single components to complex multi-axis solutions, including controllers, drives, and application-specific firmware, as well as software.

Discover what PI can do for you.

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