PI

»DRIVING INNOVATION

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.

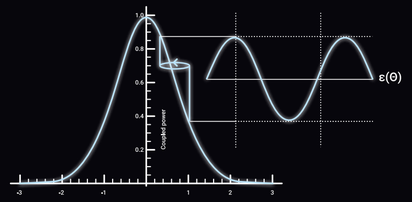
Start your digital experience and get inspired by our innovations

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.

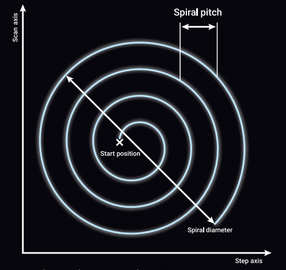
But before the optimization process can even start, an optical signal, above the noise level, needs to be detectable: This process is called first light detection. It is particularly time-consuming in devices with inputs and outputs where both sides must be lined up for even a threshold amount of coupling 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.

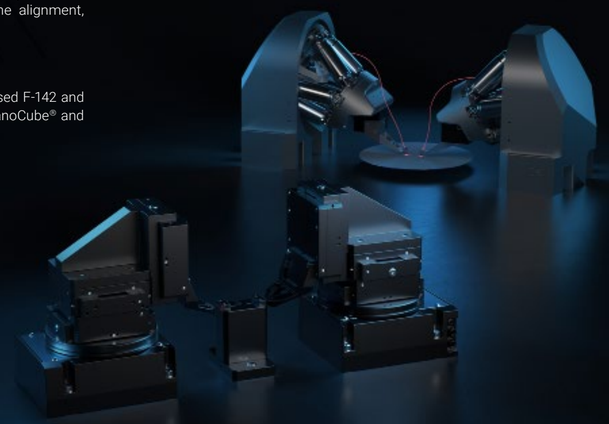
Single-Sided and Double-Sided Alignment

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!

High-Precision Motion and Control Solutions for Your Applications

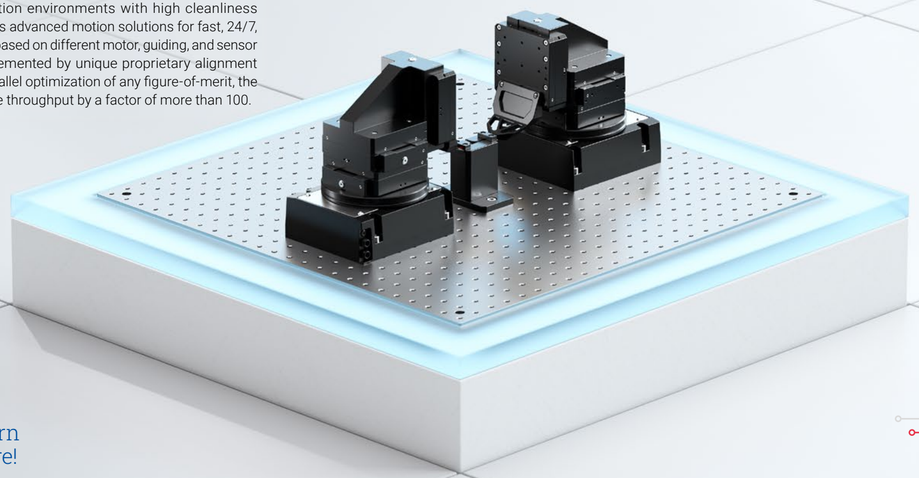
Turning ideas into advanced motion solutions that enable our customers to improve their applications and shape future markets is what drives us at PI. Thanks to our in-depth expertise in piezo technology, nano positioning, and performance automation—combined with a wide range of technologies and a high 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.

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

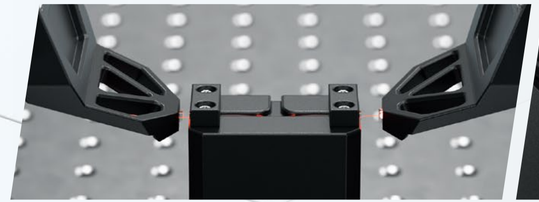
- High-performance industrial controller with onboard ACS-based alignment algorithms
- Proprietary firmware provides fast area-scanning algorithms for first light detection, as well as gradient and centroid algorithms for peak coupling.
- Software support for common operating systems, as well as for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

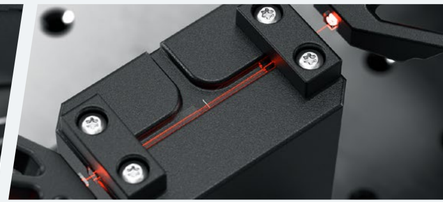
>> A-81x PIglide Motion Controller

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

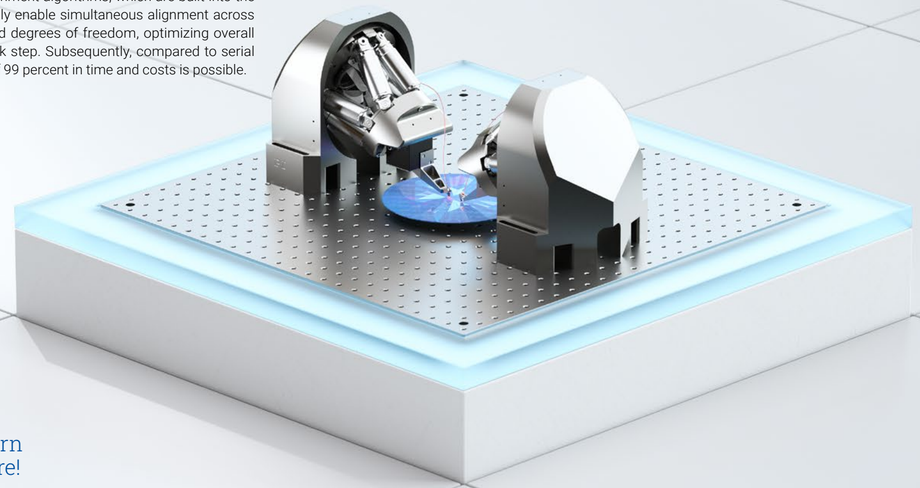




Test and Assembly of Photonic Devices

Fast Multi-Channel Active Alignment

Integrating photonic structures or elements such as waveguides, photodiodes, lasers, and multiplexers presents a variety of demanding challenges to test and assembly processes, starting at wafer level through to final packaging. The common theme: multiple channels, multiple elements, and multiple interacting inputs, as well as outputs, across multiple degrees of freedom, all requiring multiple alignment optimization. Traditionally, this is a time-consuming and expensive task. PI's Multi-Channel Photonics Alignment (FMPA) systems and unique proprietary alignment algorithms, which are built into the controller, automatically enable simultaneous alignment across channels, devices, and degrees of freedom, optimizing overall alignment in one quick step. Subsequently, compared to serial operation, reduction of 99 percent in time and costs is possible.



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

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

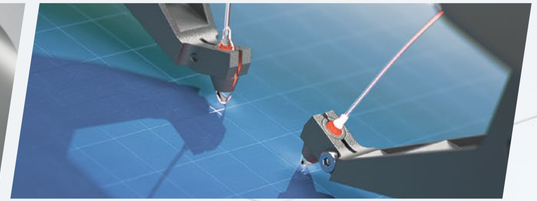
>> H-811 6-Axis Miniature Hexapod

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®

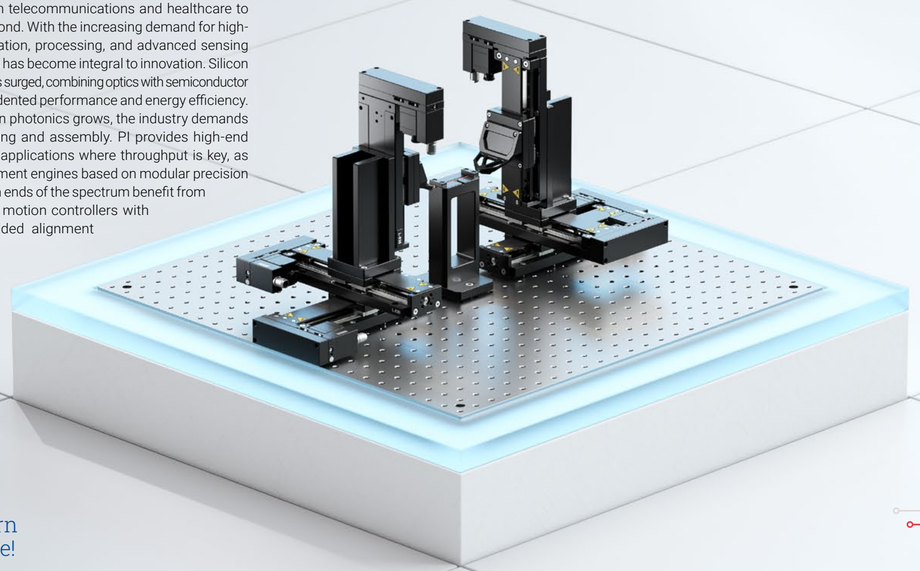
>> E-712 Digital Piezo Controller



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!

DRIVEN BY ACS MOTION CONTROL
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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

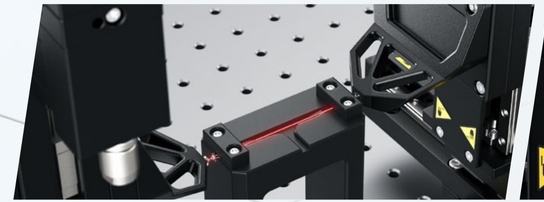
- Highly accurate and repeatable rotation
- Choice of direct-drive and worm-gear designs
- Closed-loop option for higher accuracy and repeatability

>> 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")

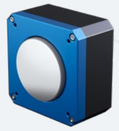
>> S-331 High-Speed Tip/Tilt Platform

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

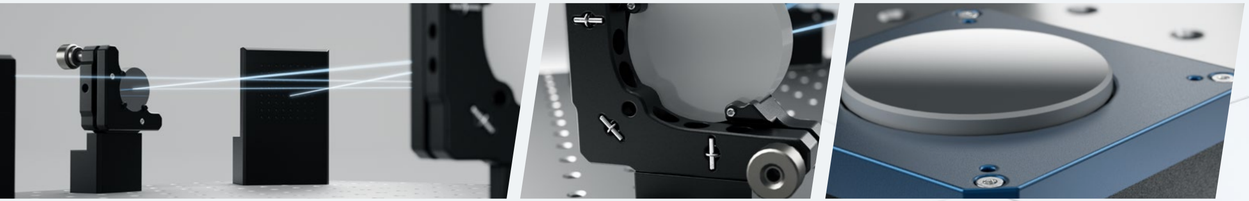
V-931 Fast Voice Coil Steering Mirror Platform

- 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



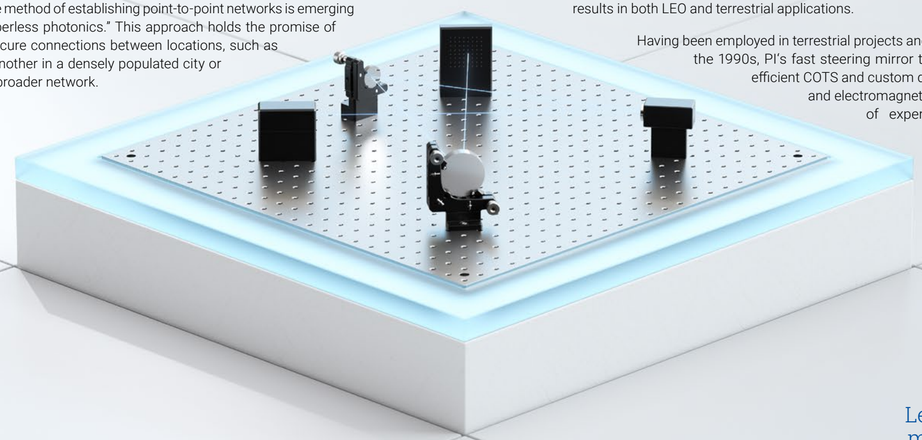
Free Space Optical Communication Enabled by Fast Steering Mirrors

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.

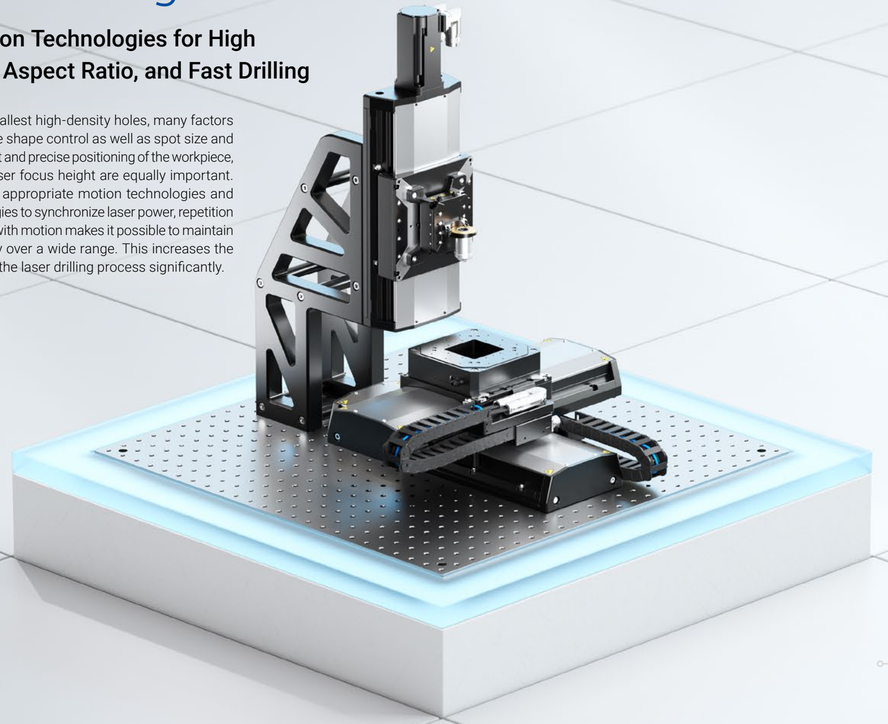


Learn more!

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.



Learn more!

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

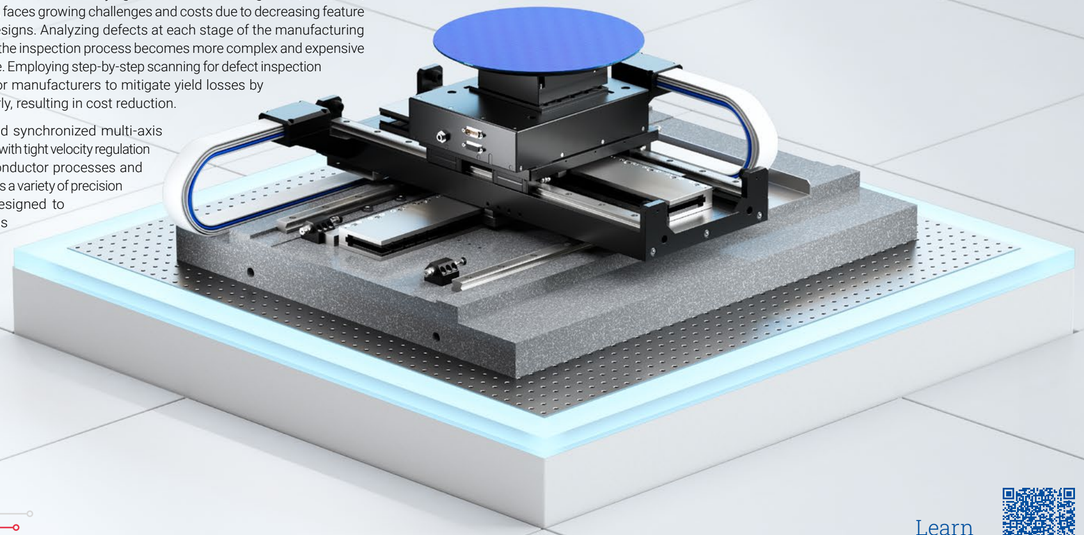
>> E-712 Digital Piezo Controller

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

Cost-Effective Scanning and Location of Defects

Wafer inspection, the science of identifying defects in the starting wafer, substrate, or the finished device, faces growing challenges and costs due to decreasing feature sizes and intricate designs. Analyzing defects at each stage of the manufacturing process is crucial, as the inspection process becomes more complex and expensive toward the final device. Employing step-by-step scanning for defect inspection allows semiconductor manufacturers to mitigate yield losses by detecting defects early, resulting in cost reduction.

Precision motion and synchronized multi-axis dynamic performance with tight velocity regulation are crucial to semiconductor processes and inspections. PI provides a variety of precision motion platforms designed to meet the rigorous requirements of process and inspection applications.



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 three-phase torque motor
- Slotless, brushless, direct-drive torque motor eliminates cogging torques and enables smooth motion with very low errors
- Precision assembly, tuning, and error compensation enable highest performance

>> Technology of Direct Drive Rotary Stages

XY Axis: Precision Step and Scan Motion

- High-dynamics, ironless linear motors for fast and precise contouring over long travel ranges
- Absolute encoders avoid referencing and ensure safety during operation
- Stiff platform with low profile reduces abbe offsets
- Design allows high flexibility and scalability
- Optimized integrated cable management reduces motion drag and prolongs lifetime
- Granite base ensures highest performance of the motion system

>> Direct Drive Linear Motor Stages

Z Axis: Precision Wafer Alignment

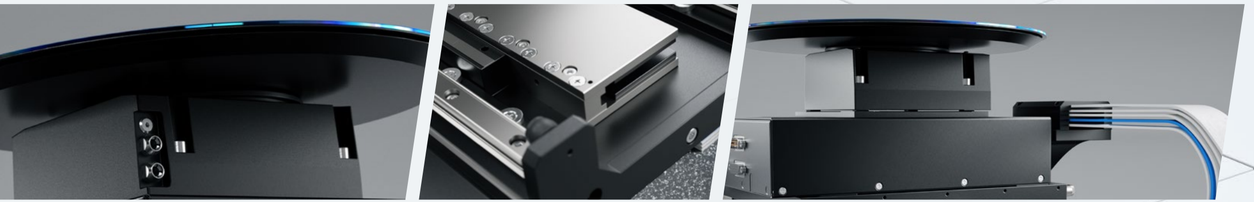
- Low profile, compact, high-stiffness mechanical design
- Direct drive ironless motor technology means zero cogging and assures smooth scan velocity and precise incremental steps
- High-resolution encoder for nanometer precise positioning of the motion platform
- High-precision anti-creep crossed-roller bearings
- Self-locking functionality at power off prevents damage
- Economically priced with fast delivery

>> Technology of Direct Drive Motors

High Performance Motion Controller

- 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

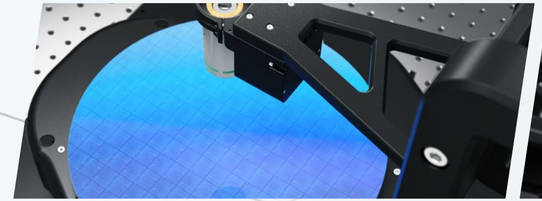
- Air-bearing planar scanner with ironless linear motors for high, cog-free scanning speed and fast stepping and settling times
- Contact and wear-free design allows 24/7 high duty cycle operations with minimal runout errors and nanometer straightness and flatness
- High-resolution absolute linear encoder 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

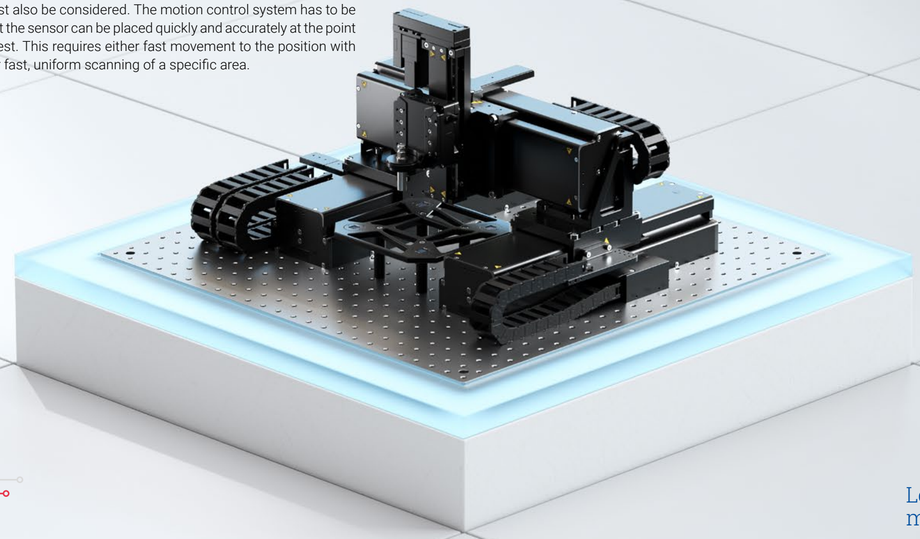
>> Motion Controller



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

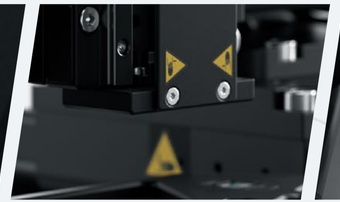
- Spot size down to 2 µm enables tiny features to be measured, as well as extremely precise positioning
- Wide range of working distances
- High resolution at fast speeds for dynamic autofocus compensation and high throughput

>> 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

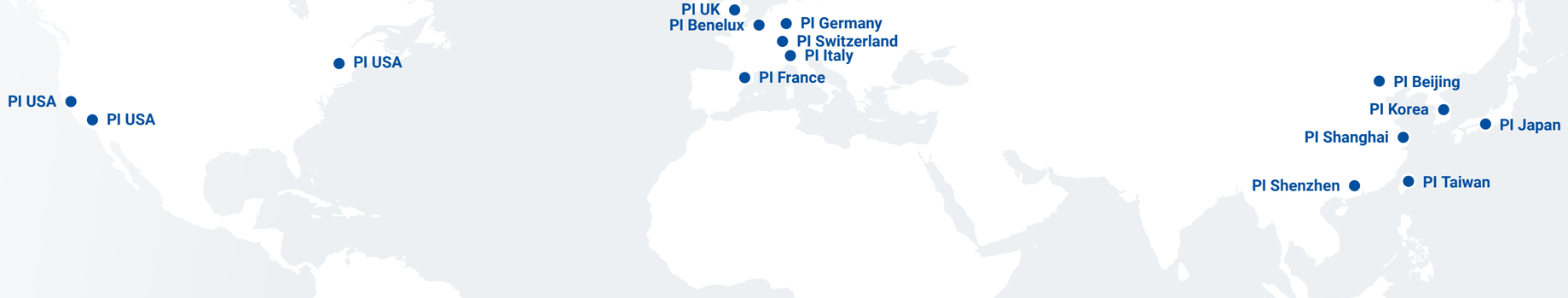


DRIVEN BY ACS MOTION CONTROL PART OF THE PI GROUP

Learn more!

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.



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