TOPICS

PIEZO NANO POSITIONING

PI

ISSUE 47

New Piezo Motor Principle for PI miCos Combines Force and Compactness

Positioner Family with Nanometer Step Size

PI miCos

PI miCos, the youngest member of the PI Group, is a specialist in compact motorized precision positioners. These are utilized in applications with restricted space, such as laboratory set-ups and mobile devices for measuring and medical technology, respectively. With increasingly smaller dimensions, classical drive systems such as DC or stepper motors reach their limits and alternative motor concepts are required.

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Piezo technology from PI

The new LPS-45 family of linear positioning stages employs PI's novel PIShift piezoelectric inertia drives providing performance characteristics not achievable with conventional drive principles. The maximum velocity is 10 mm/s, the maximum drive and holding force is 10 N. Featuring a width of only 45 mm and 48 mm length (for the 13 mm travel version) LPS-45 series stages are smaller than other systems of comparable force: A model with 25 mm travel (63 mm length) is also available.

Precision in small spaces

The LPS-45 footprint is large enough to employ the precision components required for meeting its design goal: high positioning accuracy.

Examples are crossed roller bearings with cage assist (no cage migration), providing for ultra-straight motion (better than 100 µrad), and a centrally mounted motor and optical linear encoder (6 nm resolution) for length measurement, reducing both tilt and measuring errors.

Due to the high resolution and position stability of the piezo motor, minimum incremental motion in the range of the encoder resolution can be achieved with 18 nanometer repeatability.

Owing to the self-locking piezo-motor principle, static position control requires very little drive current avoiding the heat generation found in other drive systems. The energy saving drive operates at 45 V and is especially well-suited for low duty-cycle applications. The high operating frequency of 20 kHz makes it virtually noise free.

Controlling the LPS-45

Closed-loop control with the appropriate E-871 motion controller is designed for fast point-to-point motion. The controller features digital USB and RS-232 interfaces and allows optimization of the settling behavior through several parameters. As a result of its networking capability, up to 16 axes can be controlled simultaneously via one computer interface. Within this network, other drive types such as stepper motors or brushless DC motors are also supported to provide maximum flexibility.

For laboratory applications, the E-871 controller supports LabVIEW, and additional shared libraries for Windows and LINUX allow implementation in existing environments.

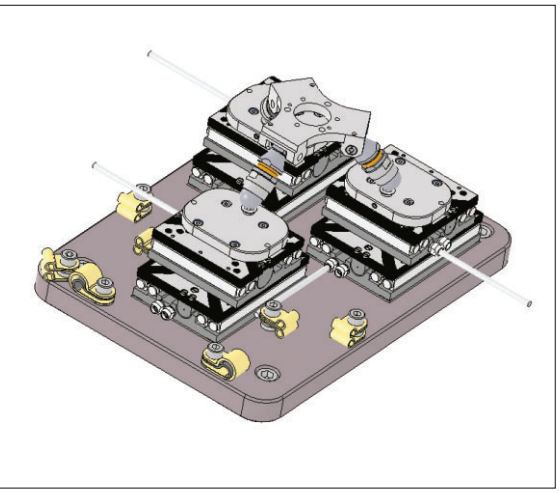
Rosy outlook

Additional piezomotor positioning systems are planned, especially for laboratory applications and beamline instrumentation.

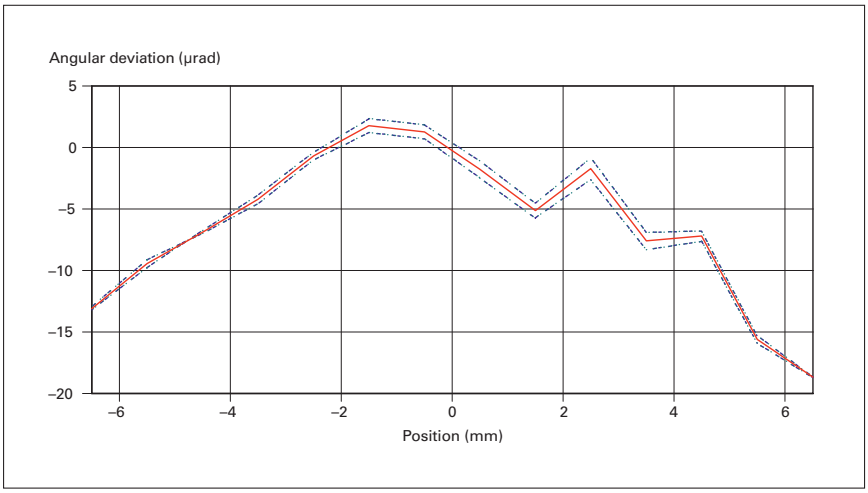
To complete the LPS-45 series, rotation stages, goniometers and Z stages will be available in the near future. In addition, the more compact LPS-23 series (23 mm width) is also in preparation and will be introduced in January 2013 starting with linear positioning stages. Here too, the goal is to achieve the best possible precision and comparably large forces.

Since piezomotors are always vacuum-compatible, LPS-45's are designed for operation in ultrahigh vacuum up to 10^{-9} hPa.

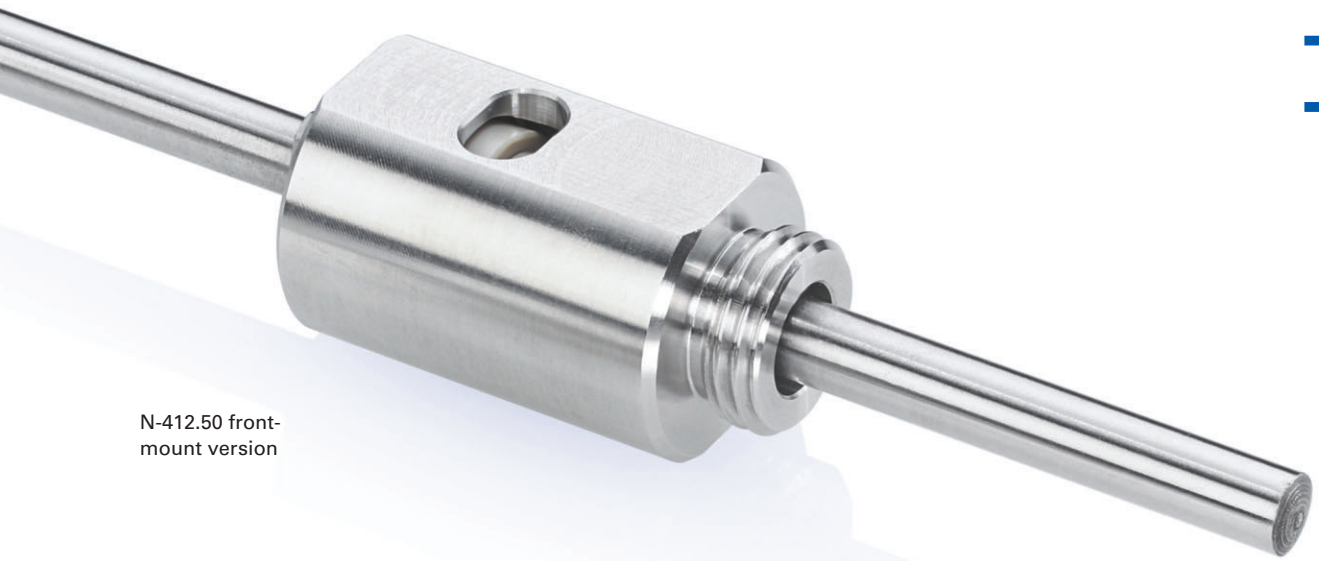
The cherry on the cake is the use of LPS positioning systems in parallel-kinematics SpaceFAB designs for motions in up to six axes – an alternative to the stacked structure of individual single-axis stages.



LPS positioning systems in a parallel-kinematics SpaceFAB design



Pitch graph: The use of high-quality guidings pays off: Angular deviation measurement (pitch). The test example shows a max. error of with 21 µrad.



N-412.50 front-mount version

PIShift: A New Compact Inertia Drive

PIShifts are space-saving and cost-effective piezo-based motors. They make use of the dynamic possibilities of piezo actuators – ideal conditions for mass-inertia-based linear drives – providing a holding force of 10 N for around 300 nm feed per full step. Due to the high motion resolution and stiffness of the piezo, the position can be precisely adjusted to a few nanometers within one step.

PIShift reaches velocities of up to 10 mm/s and works almost noiselessly, owing to its high operating frequency of more than 20 kHz.

The load is coupled to the moving rod making it easy to use the drive in typical applications such as the adjustment of optical and opto-mechanical components or cell manipulation. It is also optimally suited for industrial applications, for example the positioning of soldering tips during the manufacturing of electronic components.

This is how it works:

The functional principle is based on a single compact piezo element that is controlled with a modified sawtooth voltage of up to 50 V. The piezo element expands slowly, taking the rod along. Upon rapid contraction of the piezo element, the rod cannot follow the piezo due to its inertia and remains stationary. When at rest, the drive is self-locking to 10 N, requires no current and generates no heat. Compared to other inertia drives, the PIShift achieves higher forces. For easy integration, the stationary body of the drive is either mounted on a flat surface or screwed in on the front.

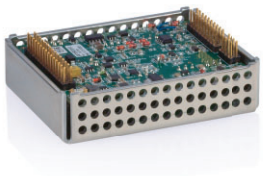
Flexible drive electronics

With the E-870 family, PI offers a series of inertia drive electronics in various integration levels. Available as an OEM board, as a variant for 4-channel serial control, and as bench-top device in a case, the E-870 combines low cost with an extraordinary ease of operation. The driver can be configured and operated via a USB interface. Windows and LabVIEW software drivers facilitate the integration in system environments.

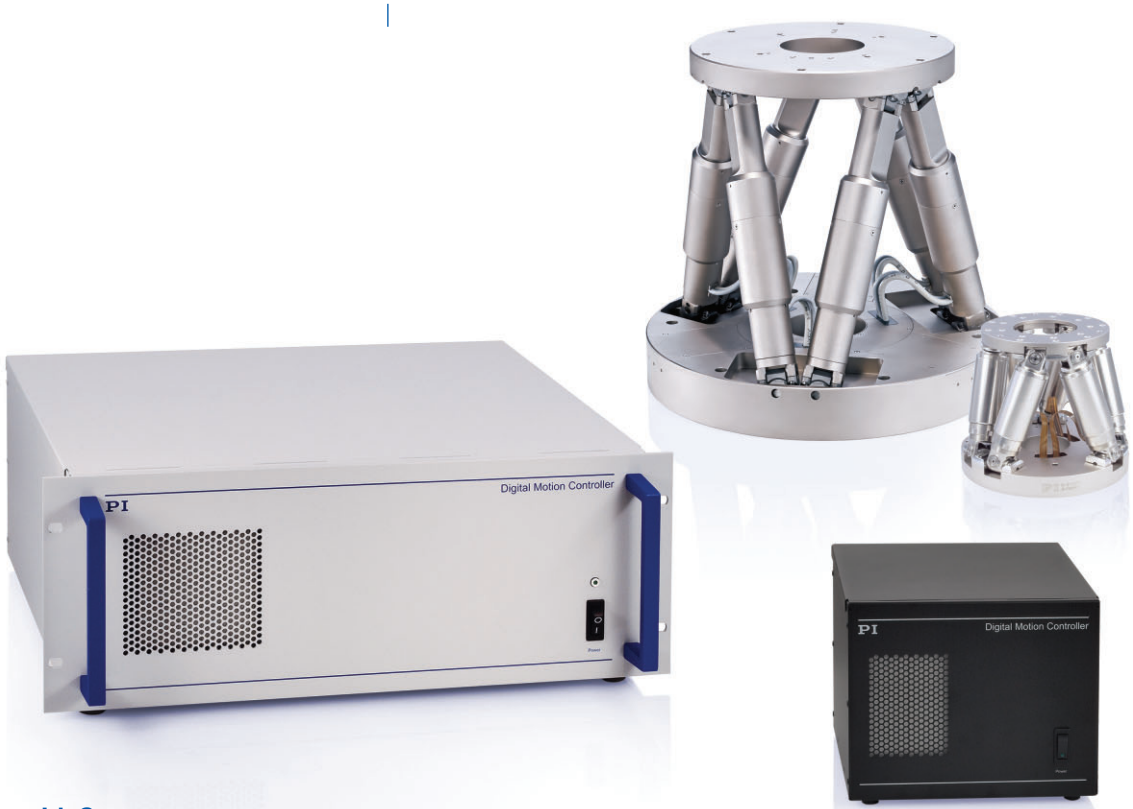
The device can also be configured and operated using hardware settings. Various operating modes allow the flexible use of the drive electronics, e.g., by means of an analog input for velocity control or TTL inputs for triggered operation. Digital outputs can be used to monitor the operating status or the temperature. PI also offers the drive electronics on a separate carrier board with easily accessible electrical contacts using sockets and terminal strips. Two push buttons on the board for forward and backward motion allow a quick start-up of the driver. The current version provides serial operation of up to 4 channels through demultiplexing.

N-422.50 PIShift linear drive suitable for mounting on an even surface

The E-870.41 allows the serial control of up to four PIShift channels through demultiplexing



E-870.10: Single-channel driver for PIShift piezo inertia drives (to be plugged in or soldered)



6-D Positioner with System

New Compact Controller for Hexapods

The parallel-kinematics 6-D positioners from PI are offered as a system including a powerful digital controller and comprehensive software support.

Each Hexapod is available in a package with a new compact controller (255 mm x 226 mm x 185 mm) that provides the full functionality at a lower system price. The Hexapod system continues to be available with the previous 19-inch rack-mount controller, now providing the control of two additional servo axes as a standard feature. Optionally, piezo systems as well as optical or analog inputs can also be connected.

At the same time, the controller firmware has been revised and the trajectory control improved further. As a new feature, a comprehensive real-time data recorder is now available for operating data such as motor control, velocity and position. Macros can be stored directly in the controller supporting stand-alone operation without a connected PC.

Commands are transmitted via TCP/IP Ethernet or serially via an RS-232 interface. Other well-known and proven features are the user programmable arbitrary pivot point and the convenient control in Cartesian coordinates.

Mini Hexapod Offers Large Travel Ranges in a Very Small Space

High Precision in Six Axes

The H-811 Miniature Hexapod offers large travel ranges in a small package of only 130 mm diameter and 115 mm height. In addition to the previously introduced vacuum version, a lower-cost system for ambient conditions is now available.

The H-811 provides travel ranges of up to 35 mm in the XY-plane and up to 13 mm in the Z-direction. It is especially the large tilting angles of 20° around the X and Y axis and up to 40° around the vertical axis that make this Hexapod so versatile. The Hexapod reliably positions loads up to 5 kg and achieves velocities up to 10 mm/s. Each individual strut has a positioning resolution of 40 nm; positions can be approached with repeatability better than 1 µm. The parallel kinematics of the Hexapods allows each axis to be positioned individually. The parallel kinematics structure is considerably more compact and stiffer than with serially stacked multi-axis systems and leads to a very high resonant frequency.

Moreover, there is no accumulation of the lateral runout and tilt errors of the individual axes. The pivot point can be selected as desired via software commands and remains independent of the motion.

Energy from Vibration – Energy Harvesting

Piezo Actuators and Sensitive Electronics Replace the Battery

If your machinery vibrates, plates or pipes oscillate, the released energy can be used to locally supply power to an electronic component and, in doing so, to dispense with batteries and their related service expense!

Piezo elements convert kinetic energy from oscillations and shocks into electrical energy. The sturdy, plastic-laminated DuraAct piezo transducers from PI Ceramic (PIC) are ideally suited to this task.

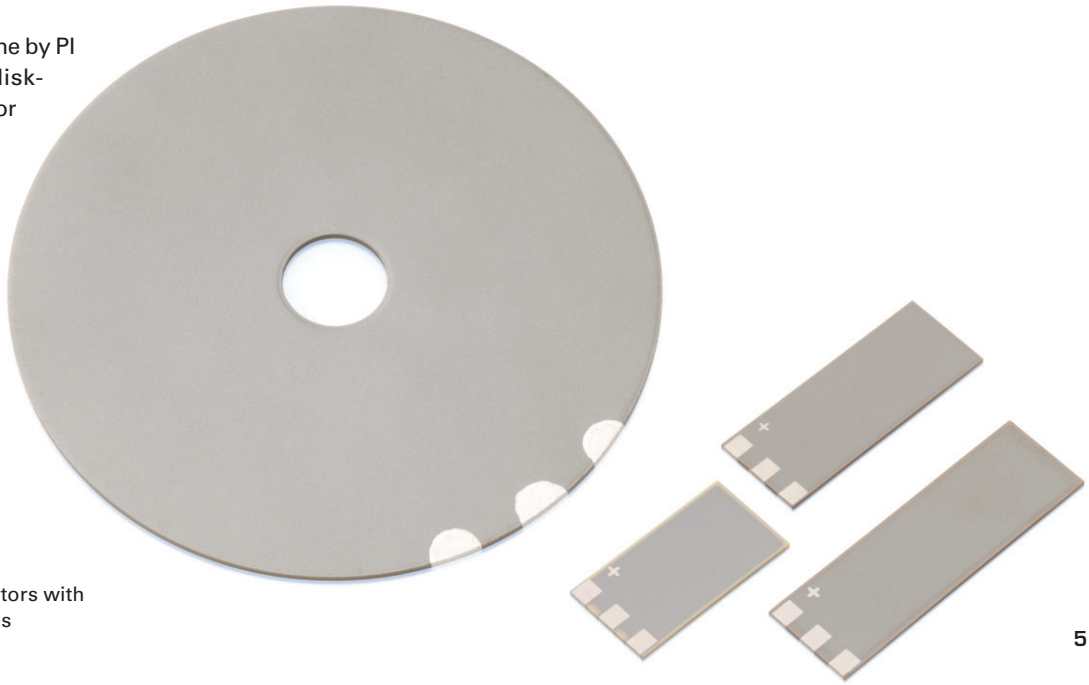
They are easy to handle and process even large displacements in the millimeter range. At the same time, they are especially reliable and durable. In addition, PIC offers corresponding transducer and storage electronics. The unit is small and can be used for almost any low-power application. The energy harvesting system works in a wide frequency range from a few hertz to several thousand hertz. It achieves an electrical peak output power in the milliwatt range, with a stable output voltage of 1.8 to 5 V for operating many commercially available electric circuits. Once a system has been successfully qualified, it can then be optimized for a specific application: The size and frequency range of the piezo transducer can be adjusted to the application, and the electronics can be adapted as desired.

The E-821.EHD energy harvesting evaluation kit contains corresponding transducer and storage electronics in addition to the piezo element.

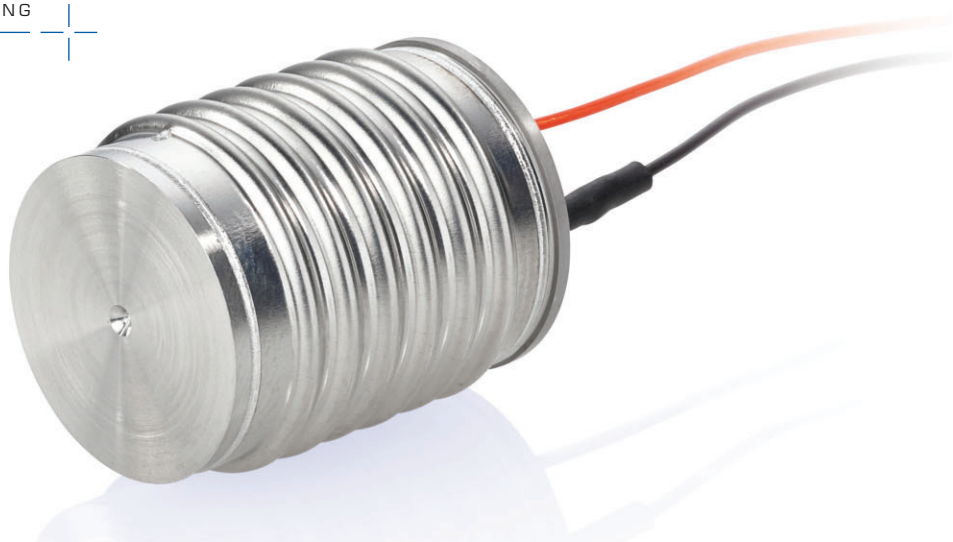
Ideal for Use in Dosing and Pumping Processes

A Disk-Shaped, Multilayer Bending Actuator Complements the PICMA® Bender Product Line

The PICMA® Bender product line by PI Ceramic now includes a disk-shaped multilayer piezo actuator in the size of Ø 44 mm × 0.65 mm for a displacement of up to 270 µm. Reliability and low operating voltage make PICMA® benders the ideal actuators for dosing and pumping applications, for optical beam deflection, and when minimally dimensioned, for use in compact portable devices.



PICMA® multilayer bending actuators with different contours and dimensions



Encapsulated Multilayer Piezo Actuators

Piezo Technology for Tough Industrial Environments

PI Ceramic offers PICMA® stack multilayer piezo actuators that are encapsulated in a stainless steel casing

The encapsulation guarantees the reliability and superior lifetime of the multilayer piezo actuators even under extreme operating conditions, such as oil, splash water or continuously high humidity.

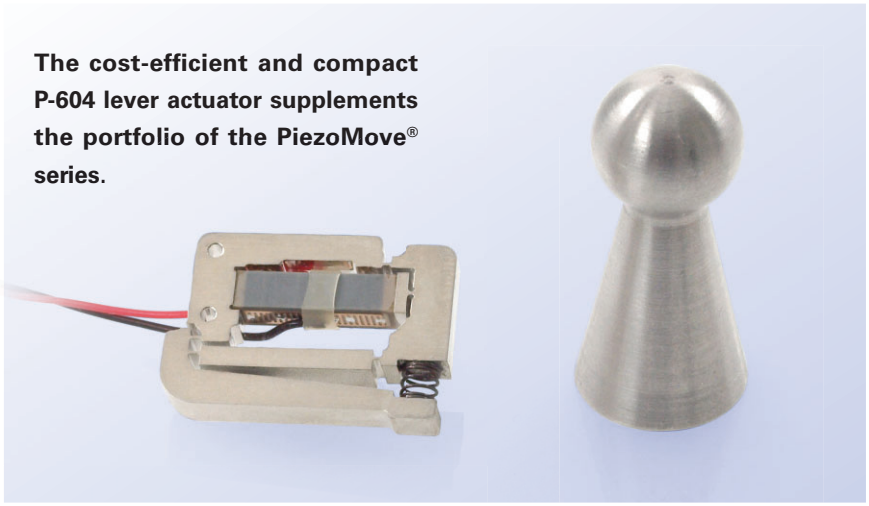
The multilayer piezo actuator is hermetically sealed in a stainless steel casing filled with dry inert gas. This encapsulation makes the PICMA® stack multilayer piezo actuators suitable for use in rough industrial environments.

The multilayer piezo actuators with stainless steel casing are UHV-compatible up to 10^{-9} hPa. A variety of sizes are offered: the 11.2 mm diameter version comes in lengths of 22.5 mm and 40.5 mm for a max. displacement of 14 and 30 µm, respectively. Higher forces can be generated with a version measuring Ø 18.6 × 22.5 mm providing a maximum displacement of 14 µm. Other sizes are available on request. The encapsulated PICMA® stack actuators can be mounted by clamping or gluing and connected through stranded wire leads.

Extremely Cost-Efficient and Compact: The P-604 PiezoMove® Linear Actuator

Lever Actuator for Small Loads, Diaphragms and Valves

The cost-efficient and compact P-604 lever actuator supplements the portfolio of the PiezoMove® series.



This new linear actuator provides a travel range of 300 µm and is exclusively designed for open-loop operation.

Due to its small size of only 19.5 mm x 13 mm x 4.1 mm and cost-optimized design for large production runs, the P-604 PiezoMove® linear actuator is an excellent choice for OEM applications in optics, medicine, biotechnology and microfluidics.

PICMA® multilayer piezo actuators are the driving force of the P-604-type lever actuators. They are extremely robust and durable due to their all-ceramic encapsulation.

Laser Beam Control and Focusing in Ophthalmology

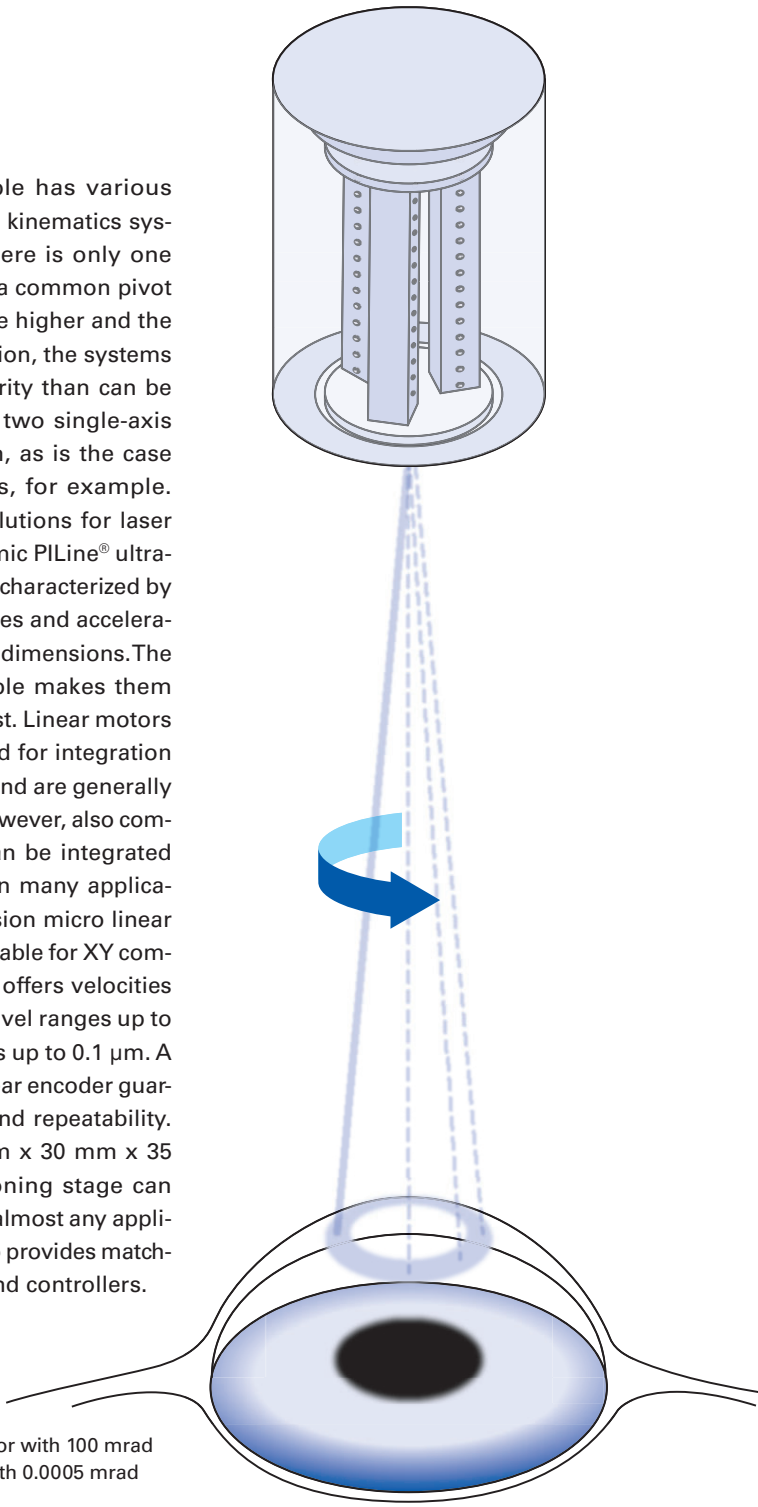
Focus on the Eye

The control and focusing of laser beams in ophthalmology requires highly accurate positioning systems. Piezo-based drives ensure the necessary precision and are fast, reliable and compact.

With the method of refractive surgery, it is now possible to compensate for ametropia into high diopter ranges. By removing corneal tissue with laser beams to model the shape of the cornea in the optical axis, the resulting refractive power of the cornea matches the length of the eyeball again. The control and focusing of the laser beam requires high-precision positioning systems.

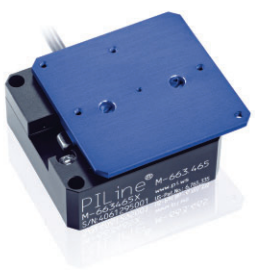
For laser beam control, piezo-driven tip/tilt mirror systems not only offer the required accuracy but high accelerations and a great dynamic bandwidth as well. They are compact in dimensions and can be easily integrated in laser systems. They allow an optical deflection area of up to 120 mrad, extremely fast response behavior (10 ms to 1 ms with mirror) as well as position resolutions into the nanoradian range. Piezo actuators are the driving force behind these one-, two- or three-axis systems.

In the case of tip/tilt mirror systems with several motion axes, piezo drives are used in parallel-kinematics positioning systems. This principle has various advantages over serial kinematics systems: for example, there is only one moving platform with a common pivot point, the dynamics are higher and the size is smaller. In addition, the systems achieve a higher linearity than can be attained by switching two single-axis systems in succession, as is the case with galvanoscanners, for example. Further positioning solutions for laser beam control are ceramic PILine® ultrasonic motors. They are characterized by extremely high velocities and acceleration with very compact dimensions. The patented drive principle makes them self-locking when at rest. Linear motors and drives are intended for integration in a customer system and are generally unguided. There are, however, also complete solutions that can be integrated ready for installation in many applications. The M-663 precision micro linear stage, which is also suitable for XY combinations if necessary, offers velocities up to 400 mm/s and travel ranges up to 19 mm with resolutions up to 0.1 µm. A non-contact optical linear encoder guarantees high linearity and repeatability. Measuring only 15 mm x 30 mm x 35 mm, the micropositioning stage can easily be integrated in almost any application. Of course PI also provides matching drive electronics and controllers.



In order to compensate for ametropia, the shape of the cornea is modeled in the optical axis by removing small cornea particles with laser beams so that the resulting refractive power of the cornea (epithelium) matches the length of the eyeball again.

PILine® micropositioning stage with linear encoder for direct position control.



Compact piezo tip/tilt mirror with 100 mrad optical deflection angle with 0.0005 mrad resolution.

PI Ceramic Publishes new "Piezoelectric Actuators" Catalog

A 70-Page Product Catalog and Reference Book on Piezo Technology Combined in One

PI Ceramic publishes its new product catalog "Piezoelectric Actuators - Components, Technologies, Operation". The new edition gives an overall view of all standard products in the area of piezo actuators as well as detailed information on the principles of piezo technology. It also contains an overview of the suitable piezo amplifiers from PI (Physik Instrumente), which can be used to operate the actuators.

With this catalog, PI Ceramic introduces numerous new standard products that reflect the wide spectrum of manufacturing technology. Among others, encapsulated PICMA® actuators, disk-shaped PICMA® bending actuators and PICMA® shear actuators for cryogenic and vacuum environments are now offered in the standard range.

For every product there are graphics and data tables in addition to application examples. PI Ceramic sets the highest priority on a flexible response to customer requests and the ability to manufacture customized products.

The second part of the catalog contains a comprehensive explanation of the principles of piezo technology together with detailed drawings. Moreover, it includes reliability and lifetime calculations for actuators, explanations of the temperature-dependent behavior of actuators and their application under different ambient conditions.

The catalog is available for download at **www.piceramic.com** or will be sent to you on request.

Headquarters

GERMANY

Physik Instrumente (PI) GmbH & Co. KG
Auf der Roemerstr. 1
76228 Karlsruhe/Palmbach
Tel. +49 (721) 4846-0
Fax +49 (721) 4846-1019
info@pi.ws
www.pi.ws

PI miCos GmbH
Eschbach
info@pimicos.de
www.pimicos.de

PI Ceramic GmbH
Lederhose
info@piceramic.de
www.piceramic.de

Subsidiaries

USA (East) & CANADA

PI (Physik Instrumente) L.P.
16 Albert St.
Auburn, MA 01501
Tel. +1 (508) 832 3456
Fax +1 (508) 832 0506
info@pi-usa.us
www.pi-usa.us

USA (West) & MEXIKO

PI (Physik Instrumente) L.P.
5420 Trabuco Rd., Suite 100
Irvine, CA 92620
Tel. +1 (949) 679 9191
Fax +1 (949) 679 9292
info@pi-usa.us
www.pi-usa.us

JAPAN

PI Japan Co., Ltd.
Tachikawa
Business Center Bldg. 5F
2-38-5 Akebono-cho
Tachikawa-shi, Tokyo 190-0012
Tel. +81 (42) 526 7300
Fax +81 (42) 526 7301
info@pi-japan.jp
www.pi-japan.jp

PI Japan Co., Ltd.
Hanahara Daini Bldg. #703
4-11-27 Nishinakajima
Yodogawa-ku, Osaka-shi
Osaka 532-0011
Tel. +81 (6) 6304 5605
Fax +81 (6) 6304 5606
info@pi-japan.jp
www.pi-japan.jp

UK & IRELAND

PI (Physik Instrumente) Ltd.
Trent House, University Way,
Cranfield Technology Park,
Cranfield, Bedford MK43 0AN
Tel. +44 (1234) 756 360
Fax +44 (1234) 756 369
uk@pi.ws
www.physikinstrumente.co.uk

ITALY

Physik Instrumente (PI) S. r. l.
Via G. Marconi, 28
20091 Bresso (MI)
Tel. +39 (02) 665 011 01
Fax +39 (02) 610 396 56
info@pionline.it
www.pionline.it

FRANCE

PI France S.A.S.
244 bis, avenue Marx Dormoy
92120 Montrouge
Tel. +33 (1) 55 22 60 00
Fax +33 (1) 41 48 56 62
info.france@pi.ws
www.pifrance.fr

CHINA

Physik Instrumente (PI Shanghai) Co., Ltd.
Building No. 7-106
Longdong Avenue 3000
201203 Shanghai, China
Tel. +86 (21) 518 792 98
Fax +86 (21) 687 900 98
info@pi-china.cn
www.pi-china.cn

SOUTH EAST ASIA

PI (Physik Instrumente) Singapore LLP
20 Sin Ming Lane
#05-60 Midview City
Singapore 573968
Tel. +65 665 98400
Fax +65 665 98404
info-sg@pi.ws
www.pi-singapore.sg
For ID / MY / PH / SG / TH

KOREA

PI Korea Ltd.
6F Jeongu Bldg.
Cheonho-Daero 1111
Gangdong-gu
138-814 Seoul
Tel. +82 2475 0060
Fax +82 2475 3663
info-kr@pi.ws
www.pi-korea.ws