

Piezo Drive Solutions

FOR MEDICAL ENGINEERING



Piezo Technology – Find Out, What’s Inside: Advanced Technology with Global Orientation

As a privately run company with a healthy growth rate, over 700 employees and a flexible, vertically integrated organization, PI can meet the most diverse requirements in the area of innovative micropositioning and nanopositioning technology and supply customers anywhere in the world with outstanding products.

PI develops and manufactures precision positioning solutions for all important markets:

- Semiconductor Technology
- Biotechnology and Medical Engineering
- Laser, Optics, Microscopy
- Precision Manufacturing
- Astronomy
- Micropositioning

Piezo Drive Solutions for Medical Engineering

Medical engineering and related life-science disciplines have a multi-faceted requirements profile for the motion drives employed: The spectrum goes from high-precision positioning systems to simple drive components which are compact, fast, reliable and energy-saving. In these fields as well, progress goes hand in hand with an increasing miniaturization. Piezoceramic drives are perfect for both these applications.

Piezo technology as drive solution has proven itself for a long time in optical metrology, micromachining and semiconductor industry. Physik Instrumente (PI) as leading manufacturer of precision positioning technology already successfully integrates appropriate solutions in a wide variety of medical applications.

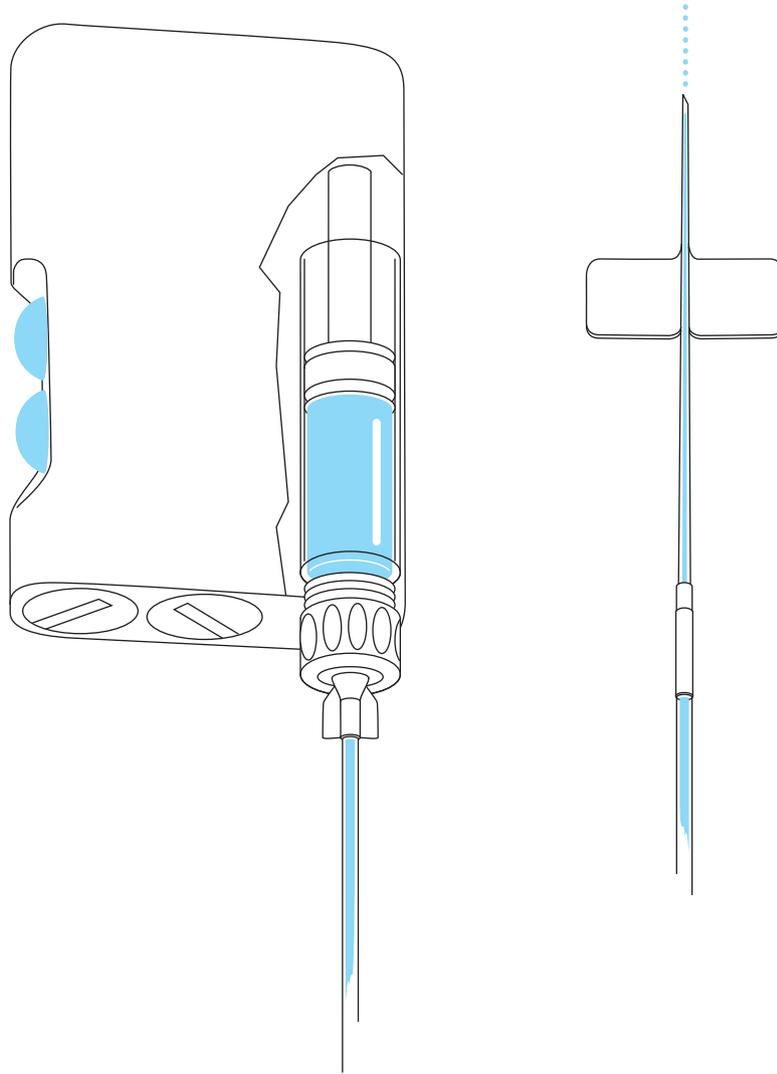
The piezoelectric ceramics are developed and manufactured in-house at PI Ceramic, a subsidiary of PI, thus PI can be very flexible in reacting to customers' requirements. PI and PI Ceramic therefore can provide a broad spectrum of drives for medical engineering: From the piezoceramic disk for generating ultrasound through to six-axis positioning systems for load positioning in strong magnetic fields.

Here, we'll show you what's inside:

- Micropumps
- Nanodispenser
- Pipettors
- Nebulizers
- Bubble detectors and flow meters

and here, you can see how drives from PI move you forward in:

- Clinical research
- Diagnostics
- Microscopy
- Therapeutic applications



Compact Design and High Performance for Micropumps

Micro-diaphragm pumps with dimensions of a few millimeters require compact drives which can provide a continuous flow and variable flow rates. The small volumes per pumping cycle mean high cycle rates of up to several 10 kHz are necessary to achieve high flow rates.

Disk-shaped piezo elements from PI Ceramic can be mounted directly on the diaphragm to deflect it. Larger ranges or forces can be achieved if a diaphragm or a piston is coupled directly to a piezoelectric linear drive.

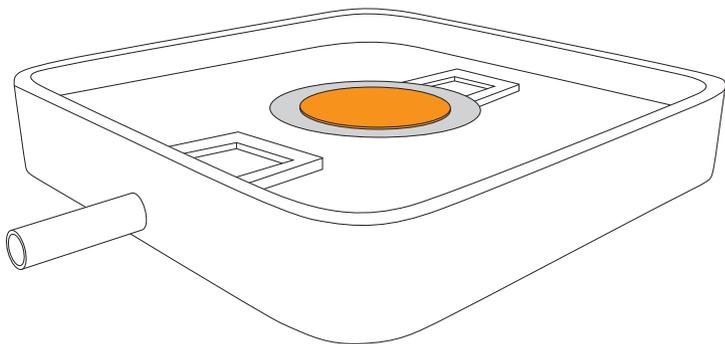
Piezo technology offers:

- Flexible Designs and drive principles: Disks and actuators or piezo motors for unlimited travel ranges
- Flexible modes of motion: Bending, arching, longitudinal and shearing motion
- High force generation for highly viscous media and high operating frequencies
- No friction, no maintenance, no wear
- Energy saving, stable position when at rest
- Large-scale production means low costs

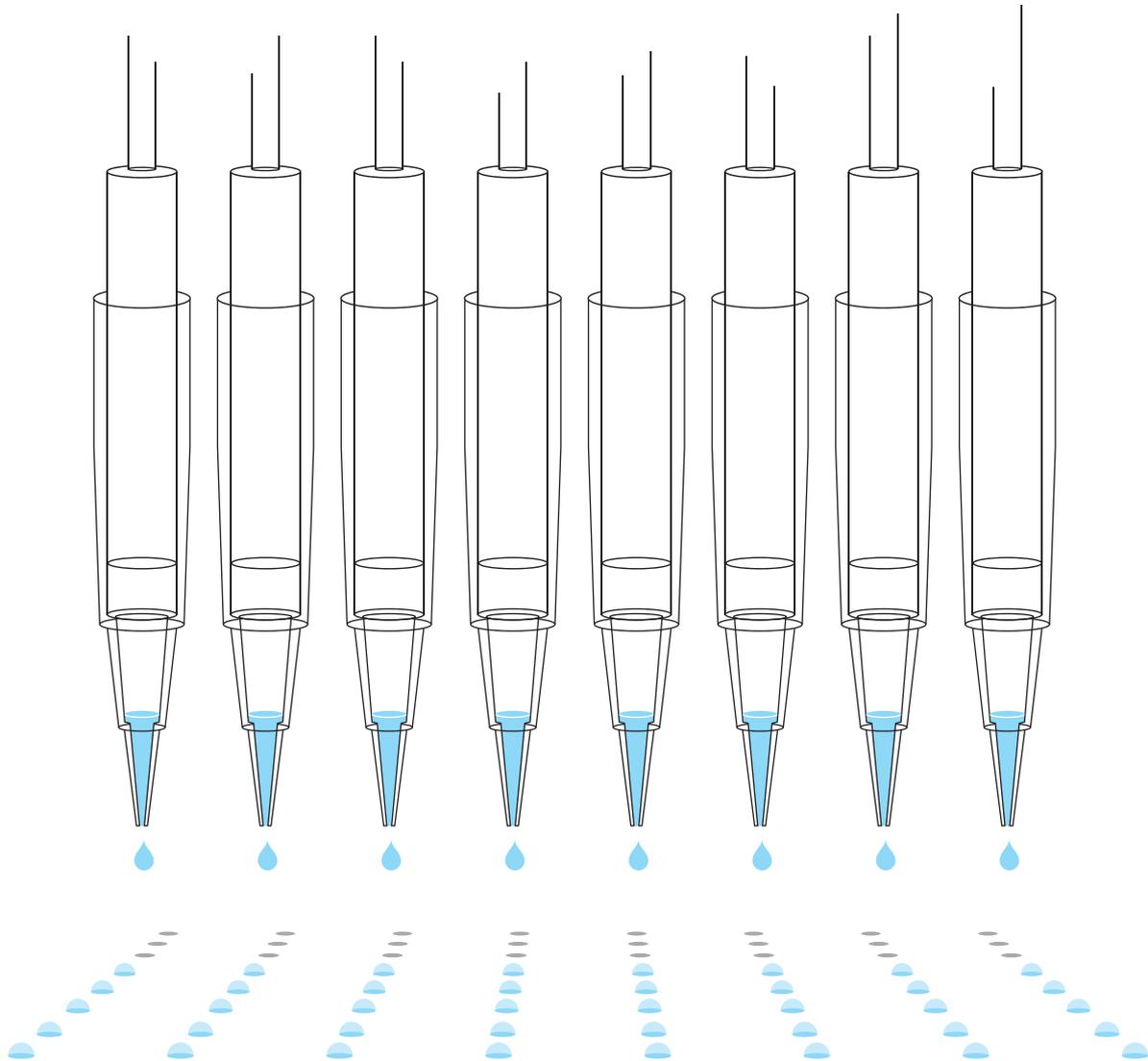
CONTINUOUS



VARIABLE



Piezoceramic disks can be attached to the membrane of a micropump and thus move it with high frequency. The continuous, slow motion of infusion pumps can also be generated with piezo drives.



Precision and Dynamics for Nanodispensers

The drives used for nanoliter or picoliter dosing devices must operate with high operating frequencies of up to several kHz and at the same time produce the kinetic energy required to generate tiny droplets without subsequent dripping, nebulization or satellite formation.

Piezo actuators are ideal for this: They can switch valves directly, and can also work against a closing spring or a flexible tube for volume displacement.

Piezo technology offers:

- Flexible designs: Benders, stack actuators
- High force generation, high acceleration, high operating frequencies
- No friction, no maintenance, no wear
- Energy saving, stable position when at rest
- Large-scale production means low costs

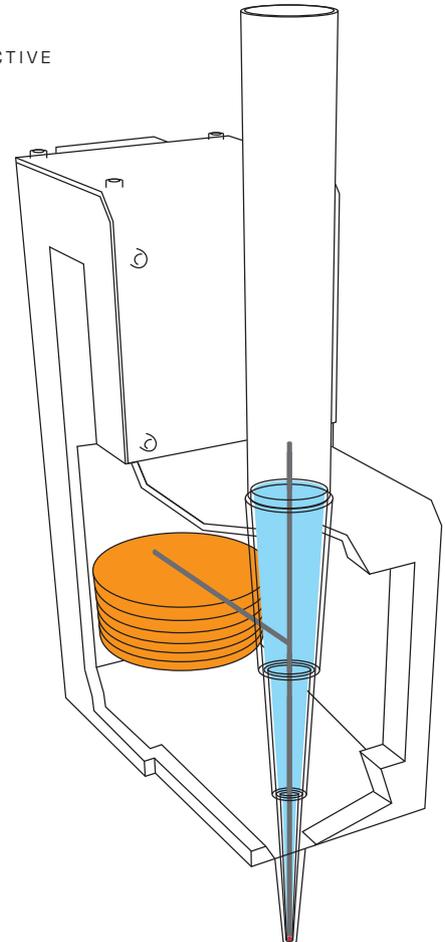
EXTREMELY ACCURATE



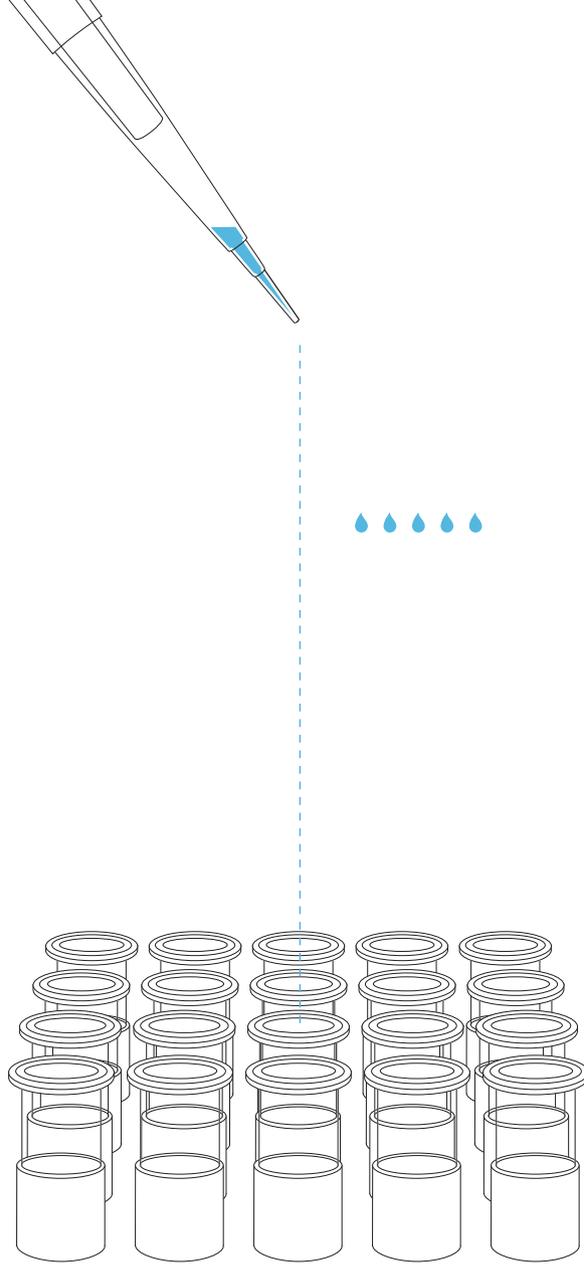
COST-EFFECTIVE



POWERFUL



Here a piezo actuator opens and closes a valve. For greater stroke the piezo motion is amplified by levers. Lift and opening duration determine the metered amount. Alternatively, the piezo doses directly in peristaltic displacement methods.



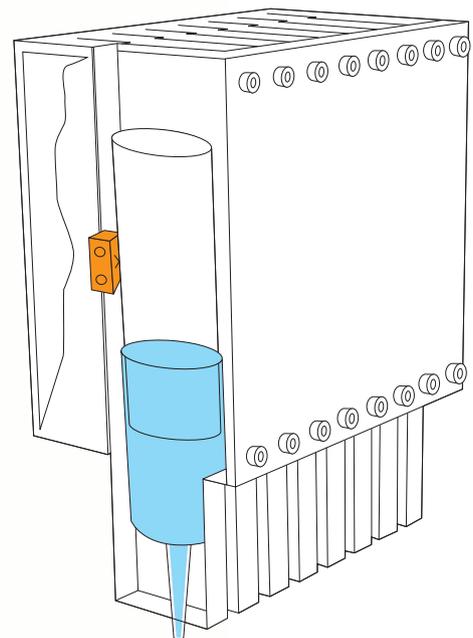
Uniform Force while Pipetting

Very small but fast drives are required to pipette with smaller and smaller devices and sample separations. At the same time they must produce sufficient force to move the pipettes in the vertical direction and to dose the media.

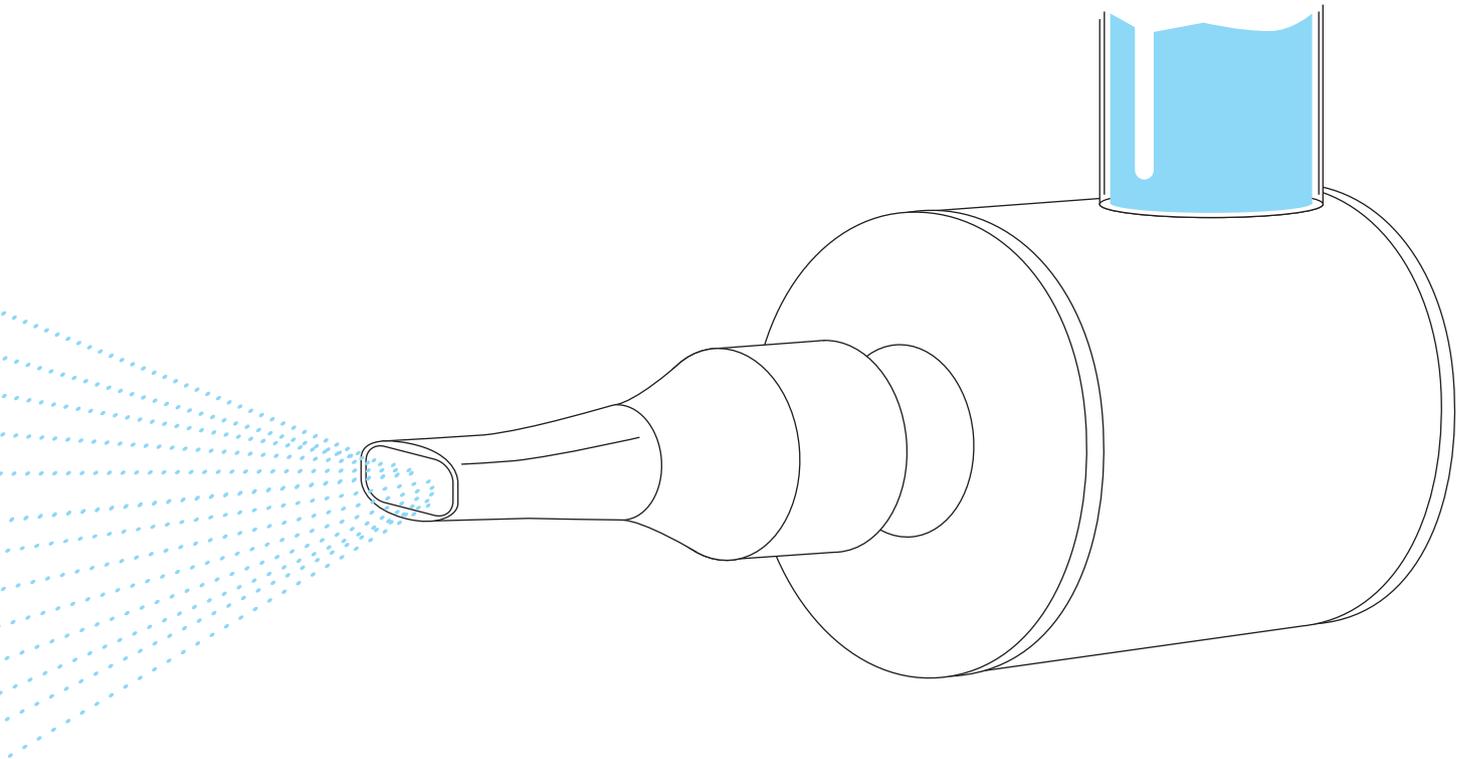
This is not a problem for piezo motors. They operate with a tiny footprint as a direct linear drive and can generate high forces. The forward motion occurs with uniform speed and can be controlled with micrometer accuracy.

Piezo technology offers:

- Compact actuators or linear motors with unlimited travel range
- Depending on application requirement: Fast, precise, powerful
- High throughput by high speed up to several 100 mm/s
- Force generation in the region of 10 N
- No spindles or gears which are susceptible to wear
- Self-locking with stable position at rest with no energy consumption
- The piezo actuators used are produced on a large scale thus keeping costs down



A compact piezo motor pushes the pipette to the target position and then moves the piston. The volumes can be varied.



Generation of Homogenous Aerosols

Medication specially formulated for the respiratory tract can be gently administered using atomizers. For accurate dosing and optimum efficacy, it is necessary to produce particularly homogenous aerosols. Specially shaped piezo membranes generate a uniform, high-frequency ultrasonic oscillation which quickly and efficiently produces droplets of a predefined size.

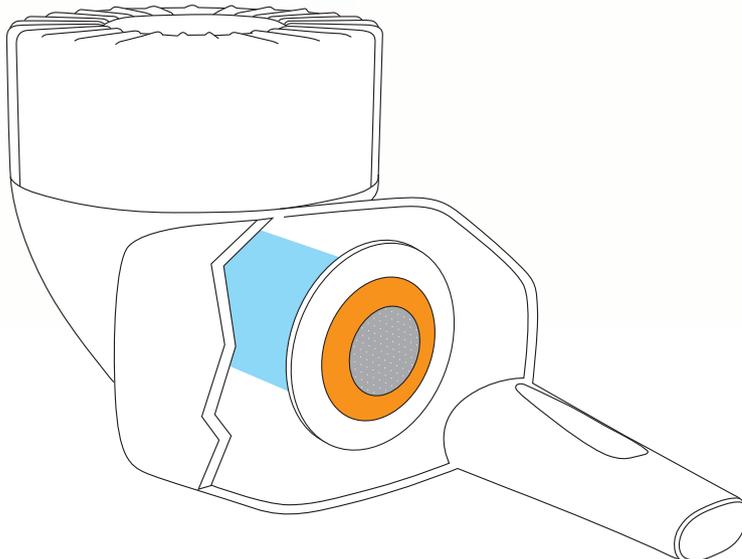
Piezo technology offers:

- Flexible designs: Rings, disks or small plates
- Flexible modes of motion: Bending, arching, longitudinal or shearing motion
- High force generation, high acceleration and high operating frequencies
- No friction, no maintenance, no wear
- Large-scale production means low costs

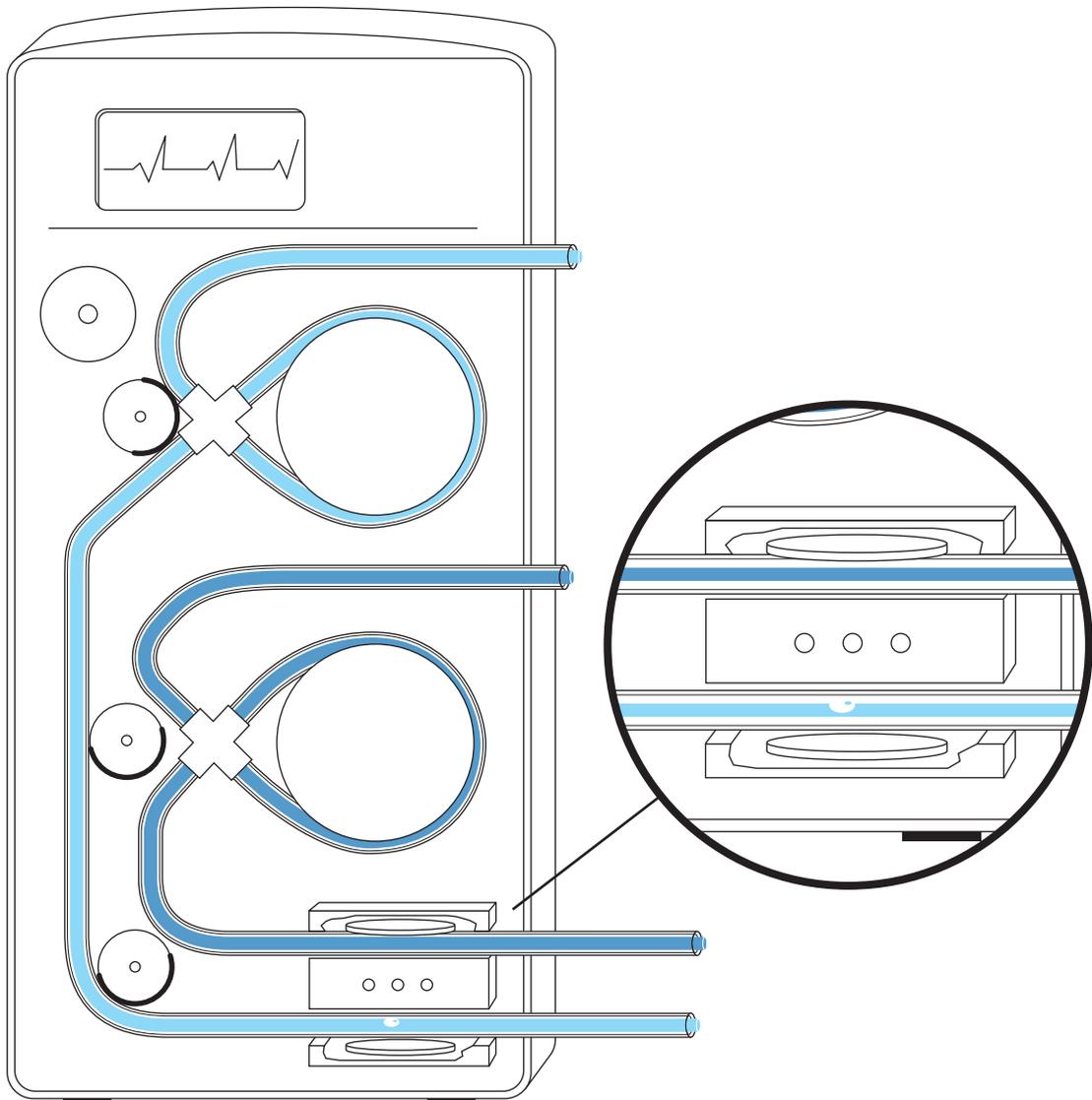
WEAR-FREE



RELIABLE



An annular piezo disk excites a perforated membrane with oscillations up to 100 kilohertz. Medication is thus quickly and efficiently atomized.



Reliable Flow Measurement and Bubble Detection

Dialysis or blood transfusions are vital and highly sensitive processes. Amongst other things, it is important to recognize air bubbles or impurities quickly and reliably. Ultrasound sensors made of piezo elements work without direct contact to the medium and need no maintenance. The sensors capture the flow velocity or they are used in Air Bubble Detectors (ABD) to detect bubbles.

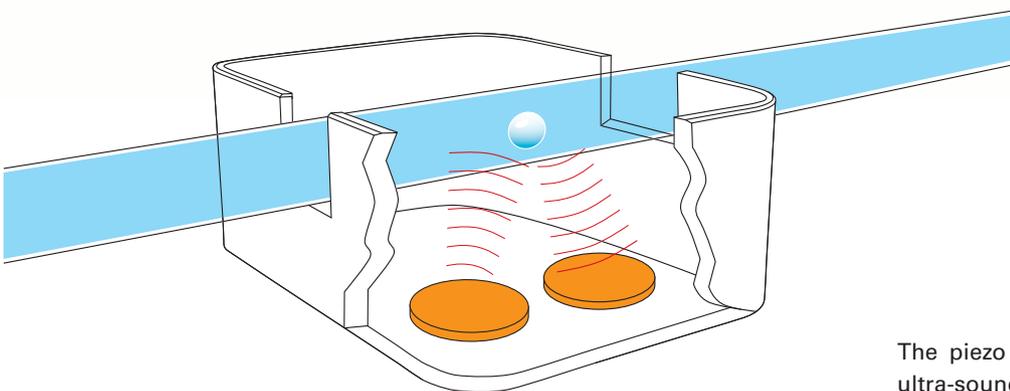
Piezo technology offers:

- Flexible, compact designs: Rings, disks, small plates
- Flexible ranges, high force generation and acceleration
- No friction, no maintenance, no wear
- The piezo actuators used are produced on a large scale thus keeping costs down

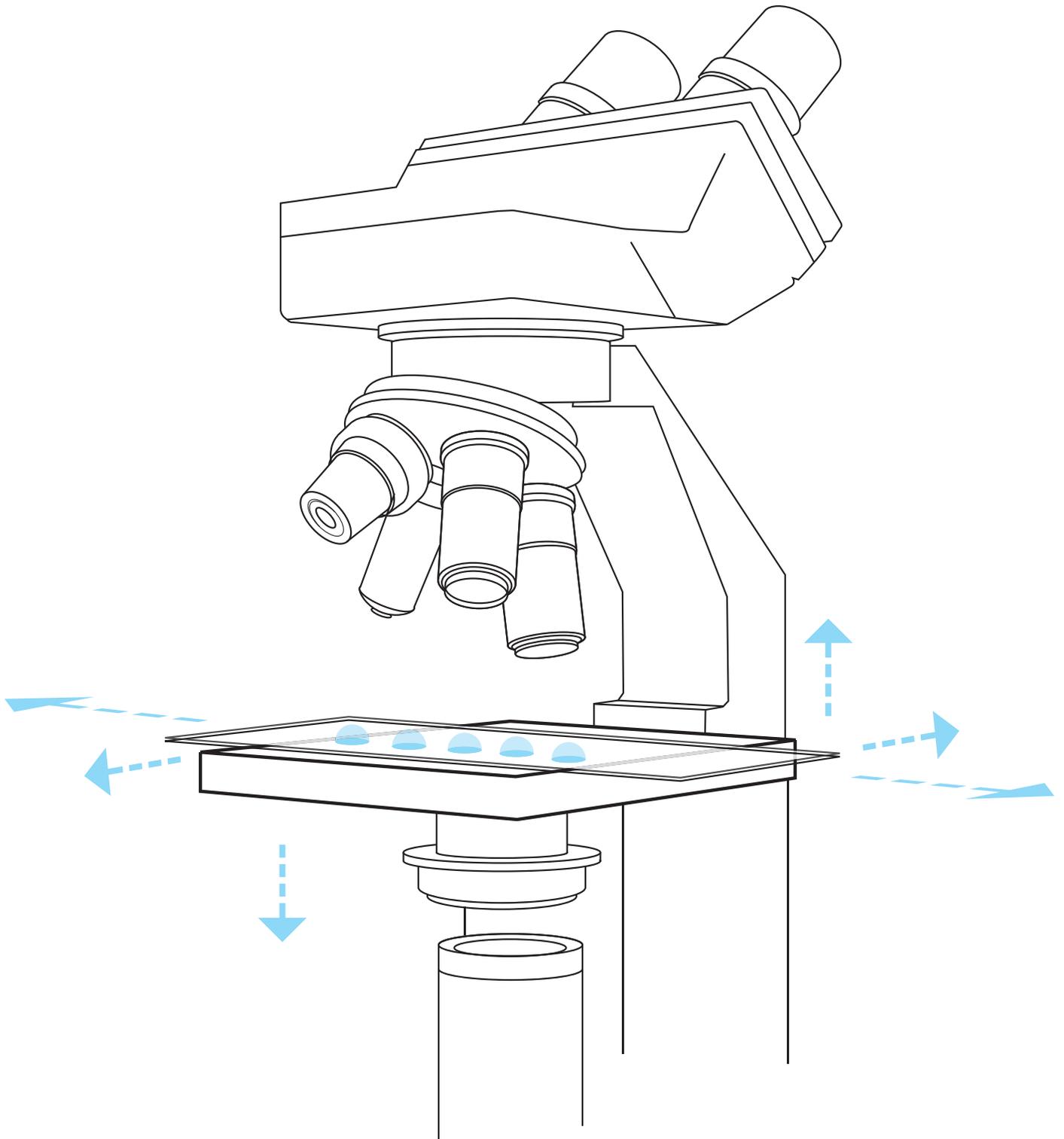
MAINTENANCE-FREE



SAFE



The piezo element works both as an ultra-sound generator and a sensor. The measurement method uses the Doppler effect: Oscillations with a few 100 kHz are reflected by the medium and reabsorbed. Frequency offsets and changes in the reflection image reliably show throughput rate and air bubbles.





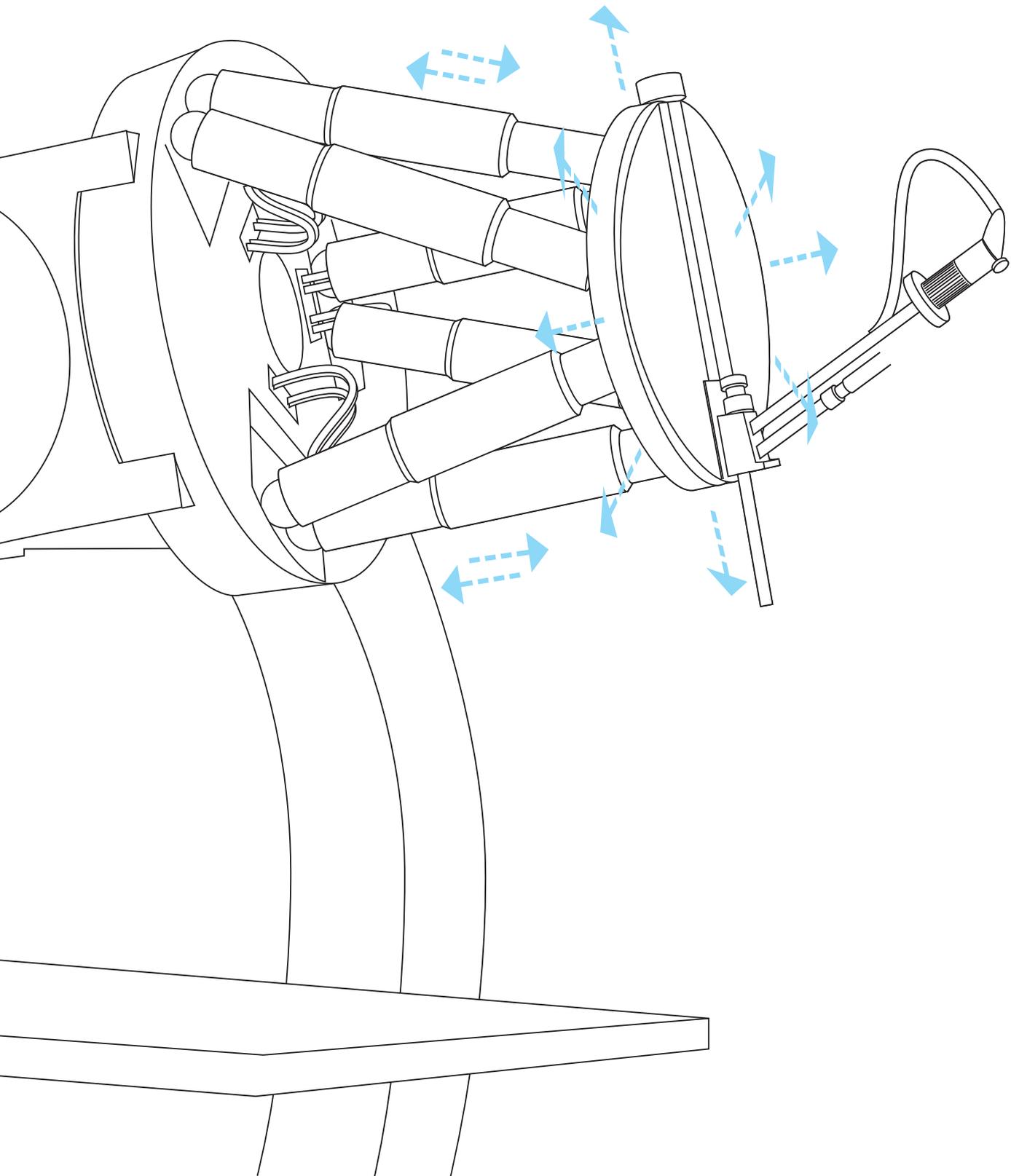
Precision in Visualization and Microscopy

Visualization is just as important in medical diagnostics as it is for example in the manufacture of implants or artificial limbs. Screening employs microscopy methods to visualize time-dependent changes caused by active agents in different dosages. With implants, optical measuring methods produce three-dimensional CAD models, making impressions unnecessary, for example. All these applications involve the movement of lenses and objects or samples.

Piezo actuators and positioning systems are just what is needed here.

PI's positioning systems offer:

- Motions along an optical axis, XY(Z) scans or 6-D motions
- Wide range of models: Piezo actuators, piezo drive systems and classic motors
- Flexible ranges of a few micrometers to several 100 millimeters
- High precision down to 1 nm and high positional stability
- High operating frequencies up to several 100 Hz
- Piezo drives mean no friction, no maintenance, no wear
- Piezo drives are self-locking: They consume no energy when at rest





Increased Efficiency for Diagnostics and Therapy

Automated processes are a step towards more efficiency – in medical engineering as well. Diagnosis and therapy get quicker and more precise and with that are more gentle for patients. Piezo drives have many application fields, for example laser beam control in cosmetic applications and ophthalmology, where they move tip/tilt stages or linear scanners and lenses with precision. Six-axis hexapod systems support surgeons in their work – they move and guide instruments or endoscopes with precision, or precisely position patients under a radiation source during diagnosis and therapy.

Positioning systems with diverse drives from PI offer:

- Flexible forms of motion right through to 6-D motion in all spatial directions
- Flexible forces of a few N up to several 100 kN
- Flexible ranges of a few micrometers to several 100 millimeters
- High positional stability and precision down to 1 nm
- High operating frequencies up to several 100 Hz
- Piezo drives mean no friction, no maintenance, no wear
- Piezo drives are self-locking: They consume no energy when at rest



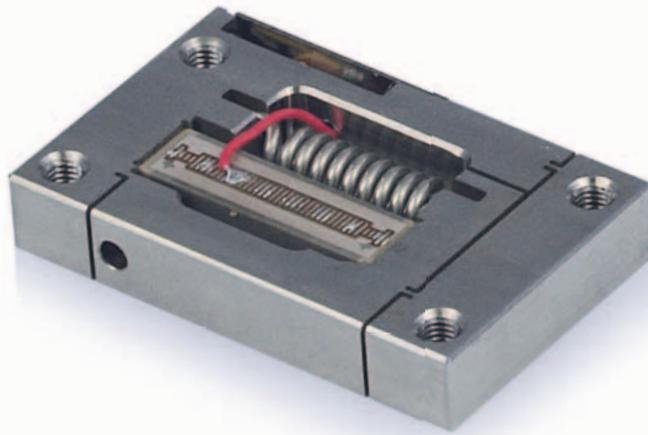
Piezo Technology from Physik Instrumente (PI): One Technology, Many Possibilities

Piezo elements convert electrical energy directly into mechanical energy and vice versa. Their motion is based on crystalline displacements, so there is neither friction nor wear. Piezoceramic components can be used as ultrasonic generators, actuators or sensors. Piezo actuators can reach larger travel ranges by layering individual piezoceramic elements. To keep the operating voltages low, the individual layers in the so-called multilayer actuators are very thin.

PI produces its multilayer actuators with the cofired technology. This technology guarantees highest reliability. The actuators are electrically insulated in a way which is humidity resistant and are used in medical engineering, e.g. in dosing applications, pumps and valves.

PI's piezo technology offers:

- Flexible, compact designs: Rings, disks, small plates, benders, stack actuators
- High sensitivity and motion resolution of less than 1 nanometer
- High operating and measuring frequencies up to several 100 kHz
- No friction, no maintenance, no wear
- They consume no energy when at rest
- Large-scale production means low costs
- Mechanically integrated systems for shielding, guiding and increasing the travel range

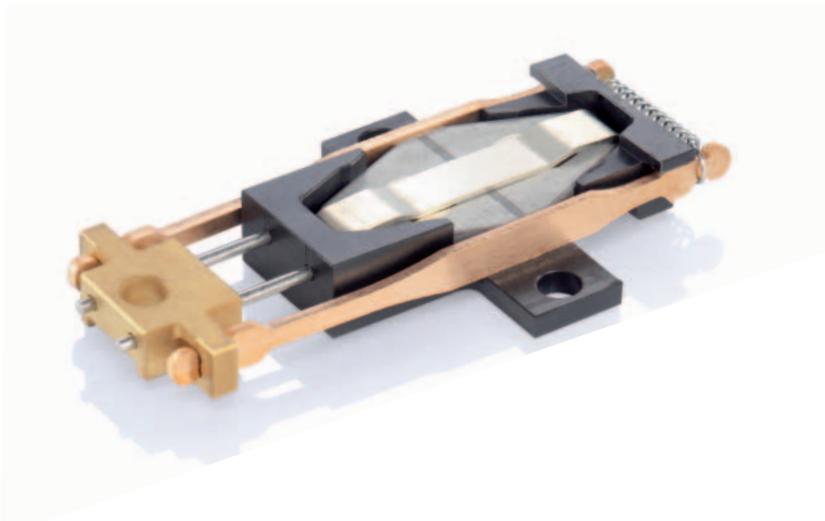


Piezoelectric Motors for Large Travel Ranges

Drives that are based on piezomotors combine the high stiffness and dynamics of pure piezo actuators with unlimited travel ranges. They also operate with high resolution in the nanometer range. This means they can always replace conventional motor-spindle combinations when these are not small, precise, fast, powerful or reliable enough. Different versions cover a wide variety of application requirements.

All technologies have however some common qualities:

- Compact design
- Different forms of integration: From linear drive to integrated positioning systems with respective electronics
- Self-locking with stable position at rest with no energy consumption
- Ultrasonic piezo linear drives: Small, fast, low cost, to around 10 N
- Piezo stepping drives: Small, nanometer accuracy, high dynamics, 10 N to approx. 500 N



Headquarters

GERMANY

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

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

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

Subsidiaries

USA (East) & CANADA

PI (Physik Instrumente) L.P.
 Auburn, MA
 info@pi-usa.us
 www.pi-usa.us

USA (West) & MEXICO

PI (Physik Instrumente) L.P.
 Irvine, CA
 info@pi-usa.us
 www.pi-usa.us

UK & IRELAND

PI (Physik Instrumente) Ltd.
 Cranfield, Bedford
 uk@pi.ws
 www.physikinstrumente.co.uk

ITALY

Physik Instrumente (PI) S. r. l.
 Bresso
 info@pionline.it
 www.pionline.it

SPAIN

Micos Iberia S.L.
 Vilanova i la Geltrú
 info@pimicos.es
 www.pimicos.es

FRANCE

PI France S.A.S.
 Montrouge
 info.france@pi.ws
 www.pifrance.fr

JAPAN

PI Japan Co., Ltd.
 Tokyo
 info@pi-japan.jp
 www.pi-japan.jp

PI Japan Co., Ltd.
 Osaka
 info@pi-japan.jp
 www.pi-japan.jp

CHINA

Physik Instrumente (PI Shanghai) Co., Ltd.
 Shanghai
 info@pi-china.cn
 www.pi-china.cn

KOREA

PI Korea Ltd.
 Seoul
 info-kr@pi.ws
 www.pi-korea.ws

SOUTHEAST ASIA

PI (Physik Instrumente) Singapore LLP
 Singapore
 info-sg@pi.ws
 www.pi-singapore.sg
 For ID / MY / PH / SG / TH

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