Piezo · Nano · Positioning

news

Issue 39 Spring 2009

Moving samples into the spotlight:

Nanopositioning systems in fluorescence microscopy

Single molecule analysis provides detailed information on chemical characteristics or biological functions, but the detection of individual molecules is by no means easy. The extremely sensitive method of laser-based fluorescence analysis is thus used to increase the signal-to-noise ratio.

Confocal microscope with single molecule sensitivity

PicoQuant of Berlin, Germany supplies the MicroTime 200 confocal, time-resolved fluorescence microscope for this task. "This system uses the time-correlated single photon count for its data acquisition and can produce both 2D and 3D images" explains Dr. Felix Koberling, Head of System Development at PicoQuant. This makes it possible to realize a variety of the methods currently used in fluorescence microscopy such as FCS (Fluorescence Correlation Spectroscopy) and FRET (Fluorescence Resonance Energy Transfer) as well as so-called fluorescence lifetime imaging. Here not only the measured intensity but also the respective fluorescence lifetime is used for the visualization and quantification in order to analyze intracellular processes even in living cells. Its modular design means the fluorescence microscope is also very flexible in adjusting to different applications. (www.picoquant.de)

Maximum repeatability thanks to dynamic digital linearization

The P-733.2CD piezo stage was the scanner system of choice for the microscope. With a travel range of 100 x 100 µm and sub-nanometer resolution, this high-accuracy nanopositioning system matches the requirements of fluorescence microscopy perfectly.

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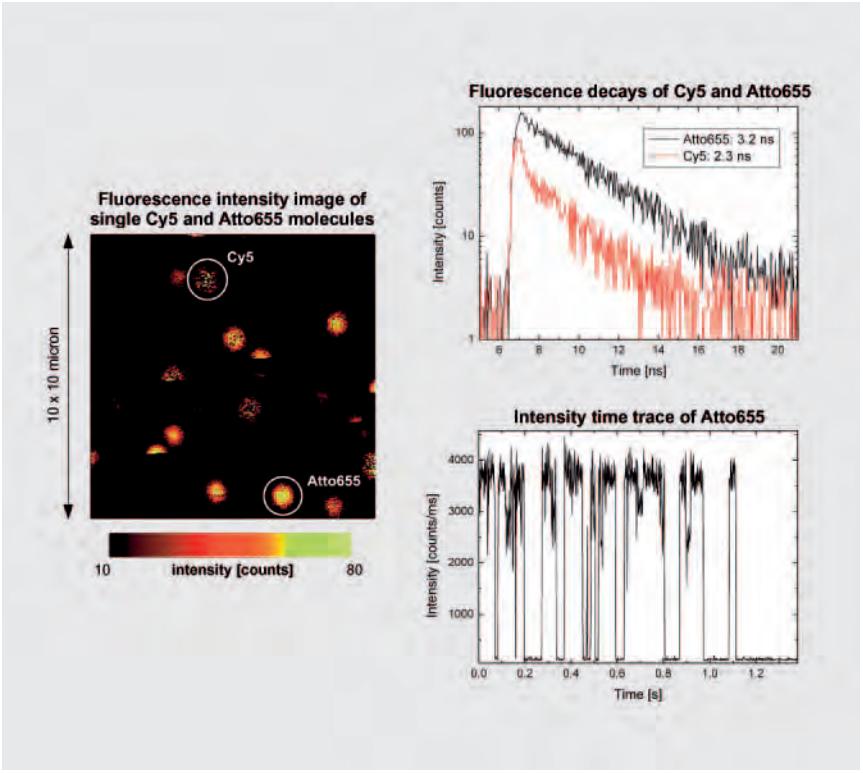
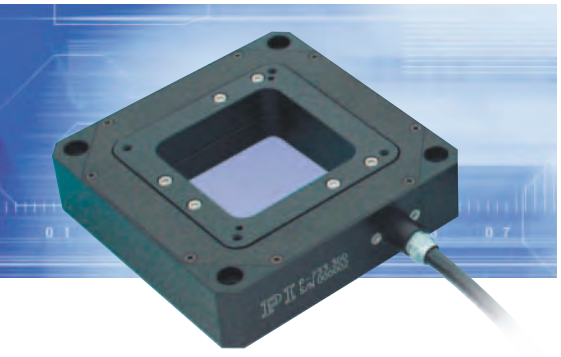
If the sample cannot be moved because it is enclosed in an environmental chamber, for example, the same positioning system can be used to the microscope objective instead. In all cases, however, the integrated direct-measuring capacitive sensors allow the scanner to produce an accurate determination of the actual position value. The first step is typically to record the image of a sample by scanning an area quickly before in a second step individual points of interest are analyzed in detail. In order to return to the exact location of these points within a few nanometers, an advanced digital control algorithm (DDL) was devised. The Dynamic Digital Linearization algorithm improves scanning linearity, i.e. repeatability by up to three orders of magnitude compared to conventional PID (proportional, integral, derivative control).

The third dimension: Additional focus adjustment

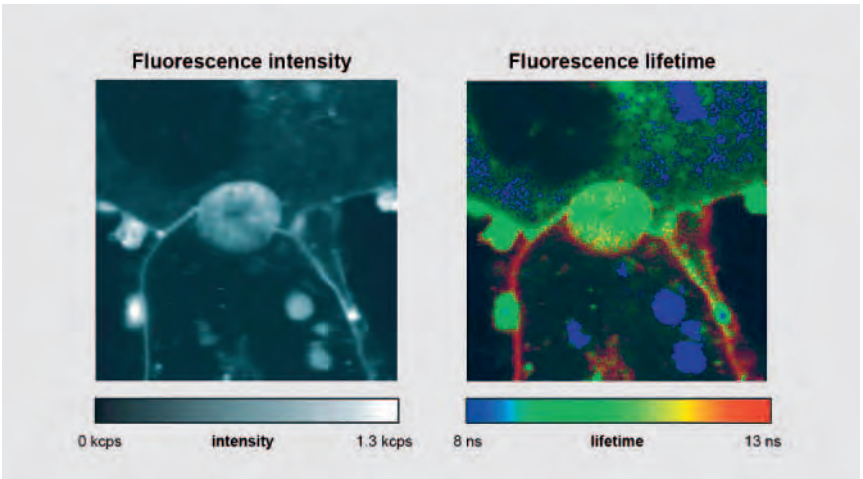
The P-721.CLQ PIFOC® Z-drives are used for three-dimensional images. They provide millisecond response times and their flexure guiding and capacitive sensors enable very accurate positioning, even when the travel ranges are relatively large. "PI's piezo-based nanopositioning systems make a decisive contribution to the fact that we can achieve very high-quality results with our MicroTime 200", says Koberling in conclusion.



Single molecule image of a mixture of immobilized Atto665- and Cy5-molecules. The single molecules can be distinguished by the fluorescence lifetime. (Photo: PicoQuant)



The P-733 piezo-based nanopositioning system provides a travel range of 100 x 100 µm. The optional Dynamic Digital Linearisation (DDL) features for digital motion controllers improves the scanning linearity by a factor of to 1000. Tracking error and phase lag are reduced to almost non noticeable values. (Photo: Physik Instrumente (PI))



Fluorescence intensity image (left) and fluorescence lifetime image of a liver cancer cell, stained with the NBD dye to analyze the organization of lipids. In the image on the right, the lifetime can be used to clearly identify different lipid structures. (Photo: PicoQuant)

Smaller – Faster – More Reliable

Demands on Safety Technology

Smaller & Faster with Piezo Motors

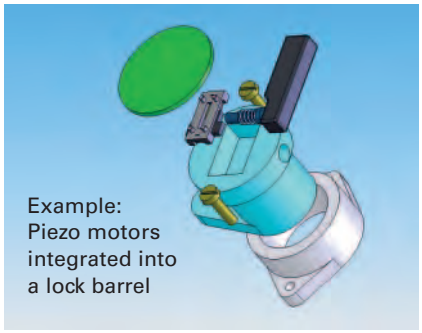
An important branch of mechatronics is the miniaturization of functional [?] systems. Compact piezo drives occupy very little space. This opens up new possibilities for locking systems because electromechanical components can be accommodated inside the door system. Modern piezo ultrasonic motors can be designed much smaller than a finger tip while providing basically unlimited travel range. Mechanical components, such as gears, leadscrews or spindles, are obsolete. Miniaturized piezo motors speed up processes considerably due to their high velocity – 100 mm/s and more – and their short response times of a few milliseconds. And this is not only the case when moving pin tumblers. Surveillance cameras must also be able to move quickly: To follow moving targets, for example, or to move lenses in focusing or zooming mechanisms.

High reliability due to simple construction

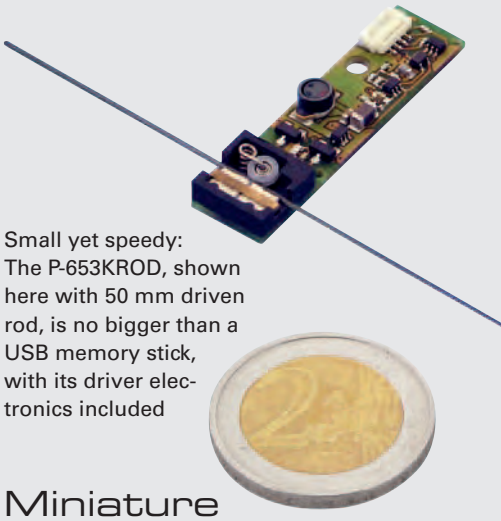
Piezo ultrasonic motors have a simple construction nonetheless: A rapidly oscillating piezo-ceramic element is pressed against a movable slider and pushes it forwards and backwards. This results in a linear motion if the movable slider is guided linearly. If the drive acts tangentially on a turntable, a rotary motion is generated. This means no additional mechanical wearing parts, such as gears, leadscrews, shafts or transmissions are required to transfer the motion. A further advantage is that piezo motors are maintenance-free and require no lubricants. A small electronic circuit induces the oscillation of the piezo ceramic. The driver is operated by a small DC voltage, which needs to be maintained only until the motion is completed. In the unpowered state the drive is self-locking.

Small drive, fewer components – low cost

Replacing various conventional mechanical components by a motor consisting only of a piece of ceramic not only reduces the size and improves the reliability: It also keeps the costs low.



Example: Piezo motors integrated into a lock barrel



Small yet speedy: The P-653KROD, shown here with 50 mm driven rod, is no bigger than a USB memory stick, with its driver electronics included

Miniature RodDrive Linear Motor

Miniaturized PILine® RodDrive linear motors position a rod extremely quickly over a travel range of several centimeters. They were designed for mechanical manipulations and for the operation of minute switches or triggers. The drive does not need to be supplied with electricity to hold its position, it does not produce heat and has no positional jitter. The miniature motor produces a drive force of up to 0.15 N at a speed of up to 150 mm/s. These miniature drives can cover an estimated 25 km during their lifetime, corresponding to more than one million cycles at a travel range of 25 mm.

The integration is simplified because the drive and its driver electronics are mounted on a compact, low power circuit board of only 40 x 10 x 5 mm in size. It is controlled by 5 volt signals and power can even be supplied via a USB interface or decentralized by means of a battery.

PILine® drives use ceramic piezo motors and are non-magnetic and vacuum compatible.

The MathWorks™

PI becomes a Product Partner of The MathWorks Connections Program – Product-independent communication interface makes integration of PI controllers into customers' MATLAB applications easy.

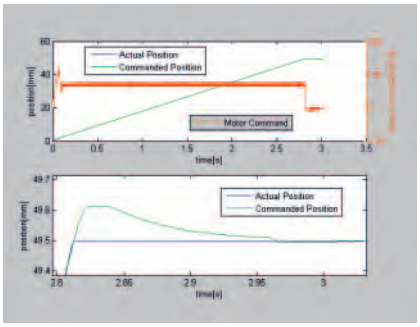
PI has become a member of The MathWorks Connections Program. This partnership is based on the PI GCS DLL interface, that offers an easy way to communicate to all kinds of PI controllers from within MATLAB, the widely used flagship product of The MathWorks.

The MathWorks Connections Program is available to third-party organizations that develop and distribute complementary, commercially available products and services based on the MATLAB technical computing environment. The MathWorks Connections Program partners help MATLAB users by providing industry or application-specific technology to fill their need for a complete solution. Partner products offer solutions that are seamlessly integrated with MathWorks products and ensure ongoing compatibility in conjunction with new MATLAB releases. With the new interface libraries, customers can easily control the various micro- and nanopositioning products by PI, import sampled data into the MATLAB workspace and use it in their own MATLAB applications.

About The MathWorks

The MathWorks is the world's leading developer of technical computing and Model-Based Design software for engineers and scientists in industry, government, and education. With an extensive product set based on MATLAB and Simulink, The MathWorks provides software and services to solve challenging problems and accelerate innovation in automotive, aerospace, communications, financial services, biotechnology, electronics, instrumentation, process, and other industries. The MathWorks was founded in 1984 and employs more than 2,000 people worldwide, with headquarters in Natick, Massachusetts.

For additional information, visit **www.mathworks.com**



Visualisation of measured Data from PI Controller

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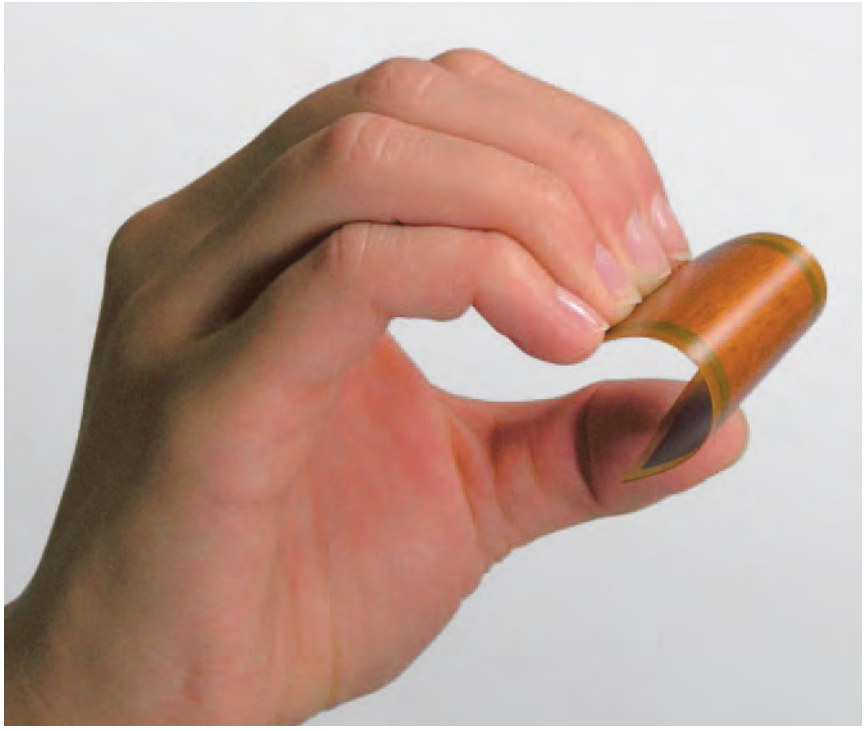
»Fachpressetage« at PI

An all-round success

On February 4, 2009 more than 40 journalists from the field of industrial automation technology gathered at Physik Instrumente (PI) in Karlsruhe. They were there for the Fachpressetage (Specialist Press Event) Automation (www.fachpressetage.de) which gave PI the opportunity to present its products on its own ground. The focus was on the PILine® piezo linear drives for automation. They complement conventional stepper and magnetic linear motors in applications where loads from a few grams up to a few kilograms must be moved with speeds up to 0.5 m/s. These drives are an attractive alternative because they take up very little mounting space, and do not require a holding current when stationary consuming neither energy nor generating heat. The visitors were impressed. "It is something completely different to see piezo motors in action rather than researching facts and writing about them!" and "An all-round success" were typical comments by the guests. The Fachpressetage are an annual event organized by the Redaktionsbüro Stutensee (RBS) marketing agency. Companies in the field of automation have the opportunity to present technological advances and new products to the journalists from leading specialist magazines and to answer any questions directly. Redaktionsbüro Stutensee is a PI strategic partner for dealing with the industrial press.

Piezo-ceramic DuraAct™ patch transducers now even thinner and more flexible



Especially thin piezo ceramics permit bending radii of less than 10 mm

The latest DuraAct™ patch transducers with dimensions of only 16 x 13 x 0.5 mm open up new fields of applications

The patented DuraAct™ transducers can be manufactured in various shapes, and specifically designed surfaces are not a problem either. Their relatively high electrical capacitance means these multi-talented transducers produce a relatively high signal yield even under difficult conditions. DuraAct™ transducers are ideal for constructing active and adaptive systems. They can be embedded in a control loop e.g. for active noise cancellation, and to control contours. Conversely, the piezo transducer generates electric voltage from a mechanical deformation and can thus be used as a small generator to supply energy to electronic components, or other energy harvesting applications.

Possible fields of application of the DuraAct™ technology are to actively increase the stiffness of lightweight structures, in medical engineering and also in the construction of adaptive optics and intelligent, self-monitoring structures.

Small, durable, intelligent – DuraAct™ in miniature format

P-876.SP1 is the smallest version of the patented DuraAct™ patch transducer consisting of a piezo-ceramic film only 0.2 mm thick.

The P-876.SP1's extremely compact size and robustness makes it suitable for use in very small spaces.

Flexible ceramics

The piezo composites become even more flexible when active films with a thickness of 80, 60 or even a mere 55 micrometers are used. Equipped with electrodes and laminated into polymer composite, these versions permit extreme bending radii of less than 10 mm. The piezo-composite element can thus also be used under the most difficult conditions. PI Ceramic has now successfully mastered the technological challenge of manufacturing and processing these extremely thin piezo ceramics.

The new DuraAct™ generation makes it possible to record vibrations up to the ultrasonic range above 20 kHz.

Sensor, actuator and energy source for applications ranging from medical engineering to the monitoring of structures

- detect vibrations up to the ultrasonic range
- smaller dimensions of 16 x 13 x 0.5 mm for new fields of application
- alternatively: thinner films down to 55 µm allow 10 mm bending radius

Physik Instrumente (PI) is now a Carl Zeiss Supply Chain Partner

Peter Schlindwein (left), Director Supply Chain Management, Carl Zeiss SMT, Dr. Karl Spanner (center), President of PI and Dr. Thomas Stammler, Director Technology Carl Zeiss SMT Lithography Optics, sign the Supply Chain Partner agreement

Physik Instrumente (PI) has been appointed a "Supply Chain Partner" of Carl Zeiss SMT, the world's leading manufacturer of optical systems for semiconductor chip fabrication. PI supplies mechatronic components for Carl Zeiss SMT lithography optics. The significance of this partnership becomes apparent when one considers that Carl Zeiss SMT has granted the status of Supply Chain Partner to only five other companies in addition to PI.

ZEISS Supply Chain Partner Carl Zeiss SMT AG

PI has been a Carl Zeiss supplier for over 18 years and supports the products of the Semiconductor Technology Division with its expertise and initiative-driven developments. Peter Schlindwein, Director Supply Chain Management (Purchasing and Supplier Support), emphasized the importance of the Supply Chain Partner program: "For three years now we have been developing strategic suppliers into Supply Chain Partners. To this end we have laid down extensive criteria, such as the conclusion of a comprehensive framework agreement, cost-reduction plans, emergency plans and various operational performance targets."

Dr. Karl Spanner, PI's President, added: "We are naturally proud to have been granted this status. We feel it acknowledges the work we have put into ensuring we always meet the high quality standards and adherence to deadlines demanded by Carl Zeiss SMT AG. Our appointment as a "Supply Chain Partner" is public recognition of this and will surely be universally recognized as a distinction."

PIFOC® – Long-range high precision focusing systems for microscopy

NEXACT® technology enables objective nanopositioning device with 1 mm travel and maximum dynamics

The new PIFOC® drives with NEXACT® piezo stepping motors are unique objective nanopositioners. They combine travel ranges of one millimeter or more with 5-nanometer resolution and high dynamics. For fast step-and-settle, the drives have a resonant frequency of 560 Hz carrying an objective weighing 200 g.

What is so special about these new systems? Conventional piezo drives have a strong correlation between the travel range and the stiffness i.e. the dynamic capability of the system. An increase in one leads to a reduction in the other. This is not the case with NEXACT® piezo stepping drives, whose operating principle allows high resolution over the full travel range and scanning frequencies up to 200 Hz over a range of 10 µm anywhere within the travel range. It is equipped with flexures for precision guidance and a high-resolution linear encoder for position feedback.

Special design of a PIFOC® with piezo stepping drive: N-310KPF6 with 5 nm resolution over 600 µm travel range

Sample nanopositioning over 0.5 mm in Z: From the specimen slide to the multi-well plate

In addition to the existing travel ranges of 100 µm and 250 µm, the P-737 PIFOC® sample positioners and scanners have been supplemented with a new 500 µm version. The Z-stages have a low profile and can be mounted on an X-Y coarse microscopy stages for fast focusing of the sample under the microscope in screening or imaging applications.

Cost-optimized, scalable design

Low-profile positioning system with piezo linear motors

Up to 90 mm travel, X, XY and XYZ combinations, speeds of up to 350 mm/s.

Delivery of components, fast switching, dosing, ... these are some of the tasks currently being undertaken in the field of automated motion control, or handling – both in biotechnology and in other branches of industry.

The main focus of motion control components in these target applications is on high-speed, cost-optimized solutions – precisely those solutions for which PI's new M-692 OEM series of stages has been designed (see also PI Newsletter 37). The stages utilize the ceramic PILine® ultrasonic linear motor making them more compact than comparable motor/leadscrew drives (construction height of only 14 mm!) while providing higher speeds of up to 350 mm/s. The integrated linear encoder provides 0.5 µm positional resolution, more than adequate for many automation and handling tasks. A further advantage is the non-magnetic and vacuum compatible operating principle. Two models are now available:

The M-692 series of stages implements the latest piezo linear motor technology and provides a cost-effective design for OEM applications

The M-692.1U4 provides 20 mm travel at up to 3 N drive force, the larger M-692.2U4 achieves up to 6 N over a travel range of 90 mm. The construction is fully scalable and the stages are suitable for direct XY mounting. An additional Z-axis can be added with a compact M-110 microstage.

Interfaces, Function Generator, Data Recorder, Display, Macro Functionality, ...

More than an interface only, the E-517 piezo control module provides enhanced functionality for system operation in precision positioning technology. In addition, to USB, TCP/IP, RS-232 and IEEE488 connectivity, a function generator with freely programmable trigger I/Os, and a flexibly programmable data recorder for control and position signals have been integrated.

The E-517 is a plug-in module for the E-500 piezo controller system. The E-500 system accommodates a variety of power amplifier modules from 1 to 3 axes and various servo controller modules for different sensor types. The units can be controlled through analog signals or via the optional E-517 digital interface module.

3 Channel Piezo Controller: the digital interface module E-517 allows digital piezo control and access to additional functionality.

Tradeshows 2009

May, 5 – 8	**Control**	Stuttgart, Germany	**Hall 1, Booth 1216**
June, 1 – 5	**Euspen**	San Sebastian, Spain	
June, 2 – 4	**CLEO**	Baltimore (MD), USA	**Booth 1915**
June, 15 – 18	**Laser**	Munich, Germany	**Hall B1, Booth 457**
July, 14 – 16	**Semicon West**	San Francisco (CA), USA	**Booth 6247**
Aug, 4 – 6	**Optics and Photonics**	San Diego (CA), USA	
Oct, 6 – 8	**Semicon Europa**	Dresden, Germany	**Hall 3, Booth 3125**
Nov, 10 – 13	**Productronica**	Munich, Germany	

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