Piezo · Nano · Positioning

news

Issue 38

3D Structuring in Nanotechnology

Novel laser lithography system which – for the first time – allows the production of complex three-dimensional microstructures and nanostructures using photosensitive materials. The precise adjustment of object or sample is achieved by using a P-563 PIMars™, a parallel-kinematics multi-axis piezo nanopositioning system (Photo: Nanoscribe)

A novel 3D laser lithography system based on PI nanopositioning technology is now available from Nanoscribe GmbH (www.nanoscribe.de). The new system allows for the first time the fully automated production of complex three-dimensional microstructures and nanostructures using photosensitive materials.

Typical fields of application for the new technology are, for example, the production of three-dimensional matrices for cellular biology, the manufacture of micro-optical components or photonic crystals and also as a rapid-prototyping instrument for microfluidic and nanofluidic systems and their production in small batches. The desired structures can be designed and then imported using any CAD software which supports the DXF format.

Track Widths to 150 nm and Below

The operating principle of the new lithography process, which is suitable for all commercially available photoresists, is easily understood: Ultrashort laser pulses are strongly focused into the material, which is then exposed by means of a nonlinear optical process in the focal point. Like a pen that is moved in three dimensions, the laser beam writes on the material following arbitrary paths. It is thus possible to achieve track widths from several micrometers down to 150 nm. Two-dimensional 2D structuring or $2^1/_2$D structuring with surface profiles are, of course, also possible and have a resolution which is significantly higher than that allowed by conventional instruments up to now.

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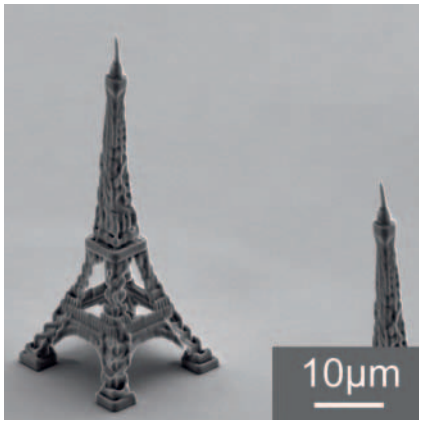
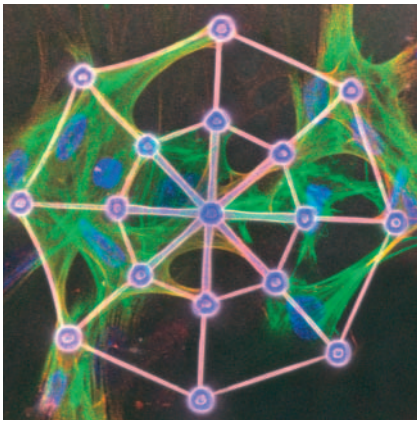
Nanopositioning in 3D Structuring

The PI nanopositioning system used by Nanoscribe for its lithographs consists of a 3-axis P-563 stage and an E-761 digital controller. The P-563.3CD PIMars™ multi-axis nanopositioning stage provides travel ranges of up to 300 x 300 x 300 µm 4 nanometer repeatability. Its construction as a parallel-kinematics multi-axis system contributes to the high positioning accuracy. All piezo actuators act on a central platform so all axes behave with identical dynamics. One "slower" axis, mostly unproblematic for linear scans, would have detrimental effects here. Moreover, the high-resolution capacitive sensors can register any deviation from the commanded path in 3D space in real time. This type of position measurement directly at the moving platform against a fixed reference (parallel metrology) allows the immediate determination and active compensation for axis crosstalk and lateral runout. The PCI-board-based E-761.3CD digital piezo controller is matched to the multi-axis parallel-kinematics piezo nanopositioning system and provides the exact trajectory control necessary for this task.



Complex three-dimensional structure: An Eiffel tower 50 micrometer in height was produced using the Nanoscribe 3D lithography process (Photo: Nanoscribe)



Cell embedded in artificial three-dimensional extra-cellular matrix. (Photo: Nanoscribe)

The P-563.3CD nanopositioning system with its E-761, PC plug-in digital controller (foreground) is ideally suited to the application because of its high positioning accuracy and travel range of 300 µm in three axes.

NEW from January 2009:

Alternative Drive Technology PiezoWalk® Linear Actuators Repackaged

The N-380 linear actuators from PI are venturing into a new performance class for linear drives:

- Large forces to 10 N and
- Speeds of approx. 10 mm/s
- At resolutions of 20 nanometers (closed-loop) or
- Far below one nanometer in open-loop operation.

The actuators have travel ranges of 30 mm for a total length of only 122 mm.

The N-381 Linear Actuator based on NEXACT® Piezo Stepping Linear motor combines dynamic motion and high position resolution with a compact form factor. The unit can be clamped at the case or mounted at the front (1/2"-40 thread)

The construction is classical: A motor moves the actuator tip to which the object to be moved is coupled. For integration, the actuator can be clamped at its case or mounted at the front by means of a 1/2"-40 thread.

The motor itself, however, is new. A NEXACT® Piezo Stepping Drive replaces the usual stepper-motors or DC servo-motors. And not without good reason.

In addition to the above-mentioned values for travel range, resolution and drive force, the piezo stepping drives offer the following advantages:

- Direct linear drive, no loss of precision as a result of converting rotational to linear motion
- High dynamics within each stepping cycle (up to 7 µm) allow fast oscillatory motions either to compensate for vibrations or to penetrate membranes in bio-handling
- The position is securely clamped when switched off. The drive does not need to be powered, so it does not generate heat and has no servo-jitter or micro-step jitter
- The stepping allows very high resolutions within one step. In open-loop operation, the motions can be resolved to about one nanometer
- The drive is made completely from ceramic so does not require lubrication and is fundamentally vacuum compatible, it is also non-magnetic and unaffected by magnetic fields

The piezo stepping drive also scores in comparison to other piezo drive principles:

- Simple inertia or stick-slip drives are based on a combination of sticking and gliding friction which makes velocity control very difficult. This limits their stiffness, lifetime and resolution.
- Piezo drives which move like an inchworm have been on the market for some years. These are also based on clamping (sticking friction), but overall do not have the same properties as the PiezoWalk® drive: They are usually larger, less powerful and considerably slower.

Movement in Micropositioning Technology

Low Cost PI Drives for Automation and Handling

M-228 Stepper Mikes offer a low-cost alternative.

Setting valves, adjusting components, pick and place ...

The specifications for these types of motion control applications differ from those PI is used to dealing with in only two respects: Not one nanometer but 10 micrometers and more are sufficient for the positioning accuracy. The price plays a much more important role, however.

Good quality and good service are two things which customers do not want to forego, which is why PI has recently received many requests from the market segments mentioned.

These requests have led to the development of the M-228 and M-229 linear actuators. These have travel ranges of 10 or 25 mm and use classic stepper motors – with either a compact (motor + gearbox) or cubic (direct drive) configuration. Despite the low prices, the user need not forego useful features such as mechanical position display, a non-rotating spindle or safety limit switches.

M-228 and M-229 are characterized by the following data:

- bi-directional repeatability: 5 µm
- unidirectional repeatability: 2 µm
- resolution 80 nm (with C-663 Mercury™ Step controller)
- backlash: 5 µm
- speed: 2 mm/sec
- positioning accuracy: 10 µm

Dispenser for Bio-Handling

PI is increasingly employing PILine® piezo ultrasonic drives in its positioning stages as an alternative to motor/leadscrew designs – particularly when the stages must be small and fast. They achieve positioning accuracies of up to 0.1 µm and speeds of up to several 100 mm/s.

Small and fast is not only a requirement in classical micropositioning technology, however. Piezo ultrasonic motors are also extremely well suited to applications where the accuracy requirements are not quite so demanding – in the range between 5 and 100 micrometers for example, which is usually sufficient for industrial automation and handling tasks.

PI has developed the low cost M-664KCEP dispenser drive with PILine® piezo ultrasonic motors for this kind of application. Eight or more of these drives stacked together can move pipettes vertically and independently of each other in order to dispense liquids into well plates. A single actuator is only 9 millimeters wide to match the standardized sample holder.

The M-664KCEP covers the travel range of 50 millimeters in less than 250 milliseconds and generates forces of up to 4 N. The resolution of the positioning sensor is matched to the application and amounts to 5 micrometers.

Stack of 8 M-664KCEP linear actuators, shown with well plate. The integrated ceramic piezomotor provides high speeds of more than 200 mm/sec.

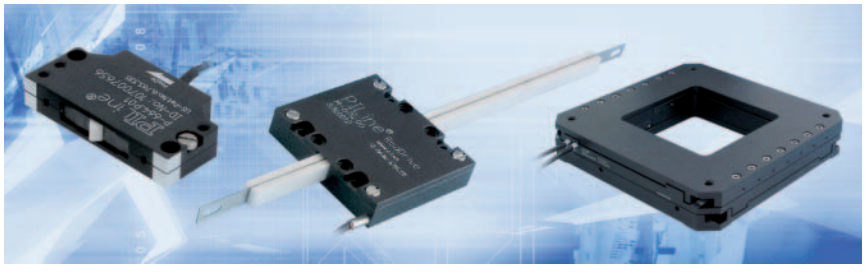
Networkable PILine® Controller for Ultrasonic Piezo Linear Motors

Simple setup and automated operation of PILine® ultrasonic motors are the characteristic features of the new C-867 controller.

This controller is based on the successful Mercury™ concept: Ready for use in no time and easy to operate, yet very powerful and low cost. Moreover, it also offers all the advantages of the Mercury™ fleet of controllers:

- networkable for multi-axis applications
- USB interface and digital I/Os
- joystick control even for several axes
- macro functionality and stand-alone operation without host PC

Compared to its predecessor (part number C-866), the controller is even better matched to the characteristics of ultrasonic motors providing optimized settling behavior and tracking accuracy. The integrated macro-processor means the controller can now also be operated in stand-alone mode. User-defined programs can be called up either via the trigger function or be started automatically after power-up. The electronic drivers required for the operation of the ultrasonic piezo motors are already integrated into the controller and are matched to the positioning stages. The increased servo input rate of 50 kHz supports the high velocity of the PILine® piezo linear motors of up to 350 mm/s (closed-loop) at a standard encoder resolution of 0.1 µm.



PILine® integration steps: OEM motor, RodDrive linear drive, XY stage

PILine® Linear Actuators / Motors

- ultrasonic piezo motors and drives
- speed up to 350 mm/s; up to 500 mm/s with open-loop operation
- compact dimensions
- travel range to 150 mm (basically unlimited)
- drive force up to 7 N
- self-locking when switched off
- encoder resolution up to 0.1 µm
- non-magnetic

Other controllers of the Mercury™ class

- C-863 Mercury™ Servo-Controller – compact and networkable 1-axis DC servo-motor controller
- C-663 Mercury™ Step Controller – compact and networkable 1-axis stepper motor controller (s. PI news 35)
- E-861 PiezoWalk® Controller / Driver – networkable controller for NEXACT® linear drives and positioners (s. PI news 37)

E-616—Compact OEM Driver/Controller for Multi-Axis Piezo Tip/Tilt Mirror Platforms

Fast tip/tilt platforms are primarily employed for beam steering and stabilization in diverse applications:

- Fast Optical Switches
- Active & adaptive optics systems
- Laser beam steering, scanning, stabilization
- Correction of polygon mirror errors
- Image resolution enhancement, dithering
- Image stabilization

The E-616 is a flexible control electronics system developed especially for multi-axis piezoelectric tip/tilt mirror platforms. It combines all functions of a multi-channel controller and amplifier and makes allowance for the peculiarities of tip/tilt platform operation. Each E-616 can be configured to run a variety of multi-axis platforms, whether tripod or four-actuator (differential-drive) design. Through the use of internal hardware coordinate-transformation, the deflection angle can be commanded directly in Cartesian coordinates, independent of the mechanical design of the tip/tilt platform. This relieves the user of the problem of external transformation in software or hardware.

Simple System Configuration

All systems are configured at the factory to ensure compatibility between controller and piezo mechanics.

The E-616 uses only one 25-pin sub-D connector for all amplifier and sensor channels, greatly simplifying the installation process.

The tip/tilt platforms of the S-325, S-330 and S-334 series will be available with the matching connector.

For operation of the E-616, a separate power supply is required.

E-616 controller with S-330 tip/tilt platform (4 mrad optical deflection)

Compact OEM XY Scanning Stage

with Servo-Motor and Linear Encoder or Stepper Motor Drives

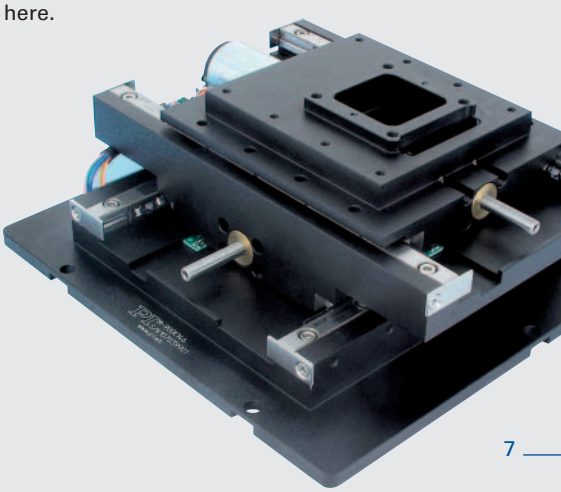
This positioning unit provides the solution for many applications where scans have to be carried out in two dimensions with high precision and speed. 50 mm travel range in both axes and a compact overall length of 170 mm provide lots of scope for the application.

The stage is equipped with DC servo-motors and high-precision linear encoders featuring a resolution of 0.1 µm. The direct drive has zero backlash and a speed of up to 40 mm/s for a load of 660 N. Models with stepper motors and further customization are available on request.

The M-900KOPS OEM scanning stage is compact in size and its clean, compact design means it can be used anywhere, for example in a white-light interferometer or a large microscope, where the sample must be positioned very accurately. PI can match the cover and base plate individually to the customer-specific installation situation.

The tried and tested PC plug-in cards of the C-843 controller series and the Mercury™ stand-alone controllers are available for a low-cost system combination; they are easy to network and provide a large number of functions for automation applications.

Integrated into a measuring unit, e.g. into a white-light interferometer, the M-900KOPS carries out precise XY-scans at high speed. A sample holder measuring 30 x 30 mm has been added here.



New Hardbound PI Catalog

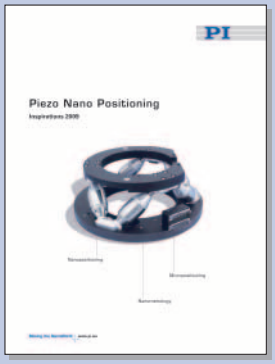
- 200 product families on more than 500 pages
- More than 1,000 products, 30% of them new
- Thousands of drawings, images, measurement graphs, illustrations of working principles

These catchwords sketch out the new edition of the PI main catalog which will be available from January 2009, initially in English. It also contains the well-known "Piezo Tutorial", of course, the reference for technology and precision positioning, everything to do with piezo ceramics.

The product groups are clearly presented in four sections: Nano-positioning with piezo-based stages, classical micropositioning, nano-metrology with capacitive sensors, and the newly added "Linear Actuators" section which introduces a range of drive technologies.

Great emphasis has been placed on the clear and consistent presentation of the technical data. Detailed overviews of the various models present the products in comparison and make it easier for the customer to select the right solution.

And in the rare event that none of our standard products matches your requirements: contact us or one of our 500 colleagues world-wide about your "Inspiration"!



Tradeshows 2008/2009

Dec 13 – 17	San Francisco, CA Moscone Center	American Society of Cell Biology Annual Meeting Booth #1624
Jan 24 – 25	San Jose, CA Convention Center	SPIE Biomedical Optics (BIOS) Booth #8627
Jan 27 – 29	San Jose, CA Convention Center	SPIE Photonics West Booth #627
Feb 28 – March 4	Boston Convention Center	BioPhysical Society Booth #

Publisher:
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