

## **25 Years of PI**

1995 is the 25th anniversary of PI. A good time for us to stop and thank our customers for their confidence in our company. Also, we want to take this opportunity to present a survey of our history, the products, customers and our future.

A quarter of a century ago, PI started designing and manufacturing products for the key Micropositioning market. Beginning with a small team of highly motivated scientists and engineers, the company soon became a world leader in micropositioning products, specifically in piezoelectric nanopositioning.

PI is a vertically structured company. We develop and manufacture all of our products in-house: electronics, mechanics, sensors, software, piezo ceramics. From the beginning, PI realized the importance of foreign markets. Over the years PI founded subsidiaries in Japan, the USA, England, France and Italy. A network of distributors supports the rest of Europe and the pacific rim. In 1993 PI founded a new subsidiary, PI Ceramic, to provide superior piezo ceramic products for the world market.

Together with sister company, Polytec, and the subsidiaries, PI employs more than 250 people worldwide, many of whom hold advanced degrees in Physics, Optics, EE, ME, and Computer Science.

The structure based on a worldwide network of subsidiaries and sister companies provides PI with the resources for continued research, development and innovation and guarantees stable, long term relationships with our customers. It has also helped PI to continuously invest in highly qualified personnel and innovative equipment even in periods when the economy was slow and other companies had to lay-off employees.

### **R&D at PI**

As a vertically integrated company and a world leader in the field of micropositioning, PI relies on its R&D department to play an important role. An international team of knowledgeable engineers and scientists, helps to maintain our lead over the competition. Sophisticated computer programs for FEA (Finite Element Analysis) simulation and CAD (Computer Aided Design) support our engineers in all mechanical and electronic design projects.

### **Customers**

At PI we fully understand the importance of our customers and always give our best to satisfy their needs. Since we are not interested in temporary success our relationships with our customers are generally a long-lasting. When PI started developing micropositioning products, most of the applications were limited to research facilities and universities. Today most of our customers are industrial leaders in the fields of semiconductor systems, medical analytical equipment, fiber-optic products, laser systems, aerospace equipment, and precision machining systems, to name a few. Of course, leading universities, technical institutes and government funded facilities all over the world use our products, too.

## Products

Our motto is "Quality, Precision, and Innovation". We use the most advanced equipment (distance interferometers, surface interferometers, spectrum analyzers, computer controlled environmental chambers etc.) to assure quality. Early on, PI adopted international quality standards. Development, design, production, assembly, service and sales processes at PI are ISO 9001 certified. Our products can be found all over the world, even places as remote as mountain tops (adaptive optics in astronomical telescopes), satellites and airborne laboratories (beam steering), and ships (fiber optic cable installation). More standard applications are in lasers, machine tools, innovative medical diagnostic systems, and semiconductor manufacturing machines.

Advanced processing methods such as EDM (Electric Discharge Machining) and computer controlled CNC precision milling, turning, and grinding machines assure the highest quality standards and provide flexibility for OEM and other special projects.

The company has been honored with several international industry awards. This Spring, our M-800 Hexapod 6-axis micropositioner was selected one of the twenty-five best products of 1994 by PHOTONICS SPECTRA, a leading US magazine. It was chosen for excellence, innovation and achievement in a sector of photonics technology.

## Future

For PI the future has already begun. On May 4, 1995 the first sod for the new Polytec PI building was turned. The building will be completed in the Spring of 1996. The additional 5500 square meters will double the office and production space available to both companies.

Advantages for PI customers: The additional space will be used to further extend the PI R&D department. New test labs, demo-, training- and meeting-rooms will further improve our products and customer service.

1970	Physik Instrumente (PI) founded in the Munich area
1976	First complete English/German catalog with 230 pages and 1000 photos
1977	Move to Waldbronn, close cooperation with Polytec
1980/1	First subsidiary in the USA, first activities in Japan
1982	Introduction of piezos for adaptive optics, fiber positioning systems, sensor equipped piezos for closed loop operation
1983	Construction of the Polytec PI office/manufacturing building Piezos for semiconductor manufacturing, precision machining
1986	Addition of three more stories on top of the Polytec PI building Introduction of low voltage (100 V) Piezos
1987	Introduction of intelligent PC plug-in DC motor controllers
1988	Introduction of monolithic piezo stages for industrial applications
1990	Refurbishing of the CNC machine shops, introduction of CAD systems for mechanical and electronic design. Founding of the Berlin sales office
1991	Founding of PI daughter company PI Polytec KK (Tokyo, Japan).
1993	Founding of PI daughter companies PI Ceramic (Germany) and Polytec PI S.A. (Paris, France together with Polytec).

Buy out of Lambda Photometrics, England (with Polytec).

1994 Introduction of fully digitally controlled fiber alignment systems  
Start of the Italian office. Introduction of capacitive displacement sensors and the Hexapod systems. ISO 9001 certification

1995 Start of the new building, participation in GSG Elektronik GmbH

The above information proves the PI motto: "Quality, Precision, and Innovation" right. We plan to continue as a reliable partner of our customers for the next 25 years (and beyond).

Caption:

PI Ceramic, Lederhose, Thuringia

The new PI Polytec Building with additional 5500 m<sup>2</sup> of office and production space will be completed in Spring 1996.

The PI Team in Waldbronn, Germany

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## PI PZT's Used as Active Struts in MIT's Stellar Interferometer Testbed

By the end of the 1990's, four astronomical observatories will be operating in Earth's orbit -- offering astronomers improvements in sensitivity and angular resolution compared to terrestrial instruments. Scientists are already designing successors to these four observatories for the decade 2005-2015 that will further increase angular resolution by one or more orders of magnitude.

Long baseline (30-100 meter) space-based interferometers have been proposed to achieve sub-milli-arcsecond angular resolution at optical wavelengths. In its simplest form, a stellar interferometer consists of three parts -- two or more widely spaced telescopes or mirrors to collect star light (called collecting optics or siderostats), a set of optics which conveys the light from multiple telescopes to a single point (called steering optics), and a set of combining optics which combines the light to form an interference pattern. By analyzing the interference patterns obtained with the collecting optics in many orientations, it is possible to assemble a very high resolution image of a distant stellar object. Obviously, this new class of long-baseline spacecraft will require precision alignment and stability in the presence of disturbances and structural flexibility.

The MIT Space Engineering Research Center's Interferometer testbed is a scaled (1:10) version of one of these space-based, stellar interferometer telescopes. A drawing of the tetrahedral testbed (constructed from 701 aluminum tubes bolted tightly to 229 aluminum nodes) is shown in the Figure. The performance requirement for the testbed is to maintain nanometer-level path length stability in the presence of vibration. To achieve this stability, Differential Path Length error (resulting from a flexible deformation of the structure that alters the relative distance light must travel from the collecting optics to the combining optics) must be controlled.

MIT designed active struts into the truss to remove this structural deformation. The core of these struts is the **Physik Instrumente P-843.60** pre-loaded PZT (see picture). This actuator can easily replace any strut on the structure, hence providing a great deal of flexibility in the control design. And the stiffness was chosen to nearly match that of the original struts. A load cell set in the load path and a strain gage on the piezoceramic stack provide load and strain sensing on the strut. A pair of accelerometers are mounted on either end of the strut as a means for measuring relative displacement of the endpoints. One end of the strut is flexured to prevent the application of bending loads to the strut through the structure. The actuators and sensors are part of a sophisticated, closed-loop system controlled by a computer. Whenever the computer senses a deformation in the structure, it activates the PZT actuators to compensate for it and maintain a stable path length for high resolution imaging. Who knows what new worlds will be discovered because of **PI's** PZT actuators?

Photo: P-843 PZT actuator as active strut. Courtesy of MIT

Drawing: Tetrahedral testbed. Courtesy of MIT

## **Harris Builds Active Isolation System with PI Low Voltage PZTs.**

The Harris Active Isolation Fitting (AIF) is an active, high stiffness, load bearing member for both vibration isolation and precision alignment. It replaces passive endfittings and joints in truss structures. Based on the PI P-845 LVPZT translator, the AIF has a 600 LB load capacity and achieves a 20 to 30 dB vibration isolation from 10 to 200 Hertz. One of the advantages of the AIF over conventional systems is that it isolates without reducing member stiffness and also provides precision structural alignment. Harris offers several controller configurations and architectures to combine several AIFs in multi-degree-of-freedom active isolator structures. The photo shows a six degree-of-freedom arrangement. AIFs can be utilized in numerous space and ground based applications involving noise abatement, vibration control and precision positioning.

Photo: Six-degree-of-freedom AIF. Courtesy of Harris.

## New 200 mm PZT Flexure Stage

The new P-915.723 Piezo Linear Stage supplements the PI family of Piezoelectric Flexure Stages and Sub-Assemblies. Based on the P-762.10 it offers twice the stroke (200  $\mu\text{m}$ ) and a clear aperture of 40x40 mm. P-915.723 is therefore ideal for optical applications such as confocal microscopy, near-field scanning microscopy or mask alignment.

As with all PI PZT stages, low voltage PZTs (0 to 100 V) and wire EDM (Electric Discharge Machining) cut flexures are employed as drive and guiding system. The EDM cut flexures are computer designed for zero-backlash and straightness on the order of 5 to 10 arc seconds. Integrated LVDT (Linear Variable Differential Transformer) sensors provide full travel repeatability of 50 nanometers.

The natural frequency of 350 Hz allows for fast positioning with settling times on the order of 5 to 10 ms in closed loop operation. The new piezo stage is compatible with all PI piezo amplifiers and servo controllers. X-Y combinations are also available.

## New 25/50 mm Linear Drive Units

The new M-224.50 and M-226.50 DC motor equipped linear drives provide 25 and 50 mm travel, respectively. They are composed of a precision micrometer screw with non rotating tip (eliminates torque based positioning errors of conventional rotating tips) and a new DC motor unit (C-136.10) with backlash-free gear head and integrated position encoder. The encoder boasts resolution of 2000 counts per revolution and allows for a (calculated) resolution of < 10 nanometers per step (gear reduction: 29.6:1, pitch 0.5 mm). Maximum velocity is 1.5 mm/sec and unidirectional repeatability is 0.1  $\mu\text{m}$ . The new drives are equipped with 15 pin D-Sub connectors and can be operated by any PI DC motor controller.

## **New Voice-Coil Scanning Stage**

The new PI voice-coil scanning stages are designed for applications where conventional screw drives are too slow and piezoelectric drives do not offer sufficient travel. The new scanning stages reach velocities up to 250 mm/s over a range of 5 mm. This unique performance is ideal for scanning (e.g. medical analytical equipment) or micro dispensing applications. The stages are equipped with integrated LVDT (Linear Variable Differential Transformer) displacement sensors. They are operated by a digital servo controller with analog, IEEE 488 and RS-232 interfaces. User-friendly LabWindows operating software is also included in the package.

Following are some highlights:

- **For fast positioning, scanning and micro dispensing**
- **Velocity up to 250 mm/s**
- **Travel: 5 mm**
- **Repeatability: 1  $\mu$ m**
- **Resolution: 0.1  $\mu$ m**
- **Linearity: < 0.2 %**
- **4 mm scans up to 20 Hz**
- **Waveforms: sine, triangle, saw tooth, step, etc.**
- **X-Y Combinations**
- **Integrated LVDT displacement sensors**
- **Digital Servo-Controller with LabWindows™ software**

LabWindows™ Graphical User Interface

X-Y Scanning stage

## **New “Products for Micropositioning” Short Form Catalog**

The 1995 PI “Products for Micropositioning” short form catalog is available now. On 12 four color pages it explains PI's product line of piezoelectric actuators, tilting platforms, fiber positioners and flexure stages, as well as motorized rotary- and linear-stages and control electronics. The catalog outlines micropositioning applications and examples of new and proven technology.

Fax or call to receive your personal copy.

## **ACTUATOR 96**

ACTUATOR is a biannual series of international conferences on new actuators; the conference started in 1988. ACTUATOR will be held in Bremen, Germany from June 19 until June 21, 1996. The conference is aimed at bringing together leading experts, scientists and managers from all over the world in the actuator field, and to transfer recent scientific and research findings to a wide range of applications. Individual sessions will be held in the following fields.

- Piezoelectric Actuators
- Magnetostrictive Actuators
- Microactuators
- Shape Memory Actuators
- Actuators based on Electro-/Magnetorheological Fluids
- Low Power Electromagnetic Actuators.

As always, PI and PI Ceramic will present new products and scientific results. More Information on the '96 ACTUATOR is available from

AXON Technologie Consult GmbH  
Hanseatenhof 8  
D-28195 Bremen  
Germany  
Tel: +49-421-175550  
Fax: +49-421-171686

or from PI.



## M-515 Linear Stages With Optional Linear Encoders.

PI introduces the new M-515 100 mm linear stage, a new member of the M-500 family. In contrast to the (still available) M-510, M-515 boasts a larger base, higher stiffness and higher load capacity.

The larger base allows for the integration of Heidenhain Corporation linear encoders for highest accuracy and repeatability.

In contrast to stages from other manufacturers, the M-500 stages are designed with the ball screw drive mechanism and the linear encoder in the center of the stage. This principle allows for better accuracy than a layout where the drive screw and the encoder are on opposite sides of the stage, thereby inducing tilt without being able to compensate for it.

The M-500 stages incorporate the LIP 402 scale, one of Heidenhain's most advanced linear encoders. This encoder exploits diffraction and interference of light offering a 2  $\mu\text{m}$  state-of-the-art signal period compared to the 10  $\mu\text{m}$  signal periods offered by conventional linear encoders.

M-500 stages offer resolution of 100 nm, with maximum velocity of up to 100 mm/sec, bi-directional repeatability of better than 1  $\mu\text{m}$  and overall absolute accuracy of 1  $\mu\text{m}$ .

M-500 stages are machined from solid forged aluminum blocks and, therefore, offer higher thermal stability than stages made from extruded profiles.

## **PI buys shares of GSG Elektronik GmbH**

Effective September 1st 1995, PI participates in the company GSG Elektronik GmbH. Founded in 1979, GSG quickly became a well known source for custom high- and low voltage power supplies for heavy duty requirements.

GSG also has a long record for MIL and Space qualified electronics. A few examples will prove this:

SAMPEX (Solar Anomalous and Magnetospheric Particle Explorer) NASA mission  
MIR HEXE (High Energy X-Ray Experiment) project (MPI-Garching, AET-Tübingen, IKI-Moscow and MBB-ERNO).  
ROSAT X-ray telescope, Max-Planck Institut for extraterrestrial Physics, Garching.

Additional products were manufactured for Krauss Maffai (multi DC/DC converter for MIL-test equipment) and Liebherr (DC/DC converter for the control electronics of mobile hydraulic cranes). GSG was awarded the "Linotype Quality Award" several times for superior quality of the laser power supply provided for Linotype's Image Setter machines.

The following survey summarizes GSG's capabilities:

### **Industrial applications**

- Wide range switching power supplies and DC/DC converters with multiple output voltages, 5-100 Watts
- High voltage modules up to 20 kV / 10 W
- Electronic transformers for halogen lamps
- High voltage igniters for HMI lamps
- Secondary switched supplies

### **New Products:**

- Computer controlled 50/60 Hz AC sources with voltage and power control up to 4.5 kW
- HV power supply modules for 19" rack mount systems with DVM display for current and voltage and optional RS-232 and IEEE 488 interface
- 19" rack mount HV power supplies up to 50 kV and 100 - 2000 W output power. A novel resonance-converter circuit boasts extremely high efficiency, superior EMC and minimum ripple.

### **Commercial applications**

- HV amplifiers for piezoelectric fiber splicers.
- HV supplies for battery operated CRTs.
- HV amplifiers for piezo actuators
- Battery operated Laser power supplies
- DC/DC converters with multiple output voltages

### **New products:**

- Power supplies with computer controlled pulse generator for CO<sub>2</sub> lasers up to 1.5 kW
- Wide range power supplies and DC/DC converters with multiple output voltages
- HV power supplies up to 50,000 V and 2000 W

### **Aerospace & MIL Applications**

- DC/DC converters with multiple output voltages up to 20 Watts

- HV supplies for ion-getter pumps up to 5 kV/10 W
- Computer controlled multiple voltage HV sources for spectrometers
- HV supplies for CRTs
- Charge amplifiers

Additional information on GSG products is available from GSG Elektronik GmbH, Gießereistr. 12, 83022 Rosenheim, Germany Tel: +49-8031-13082 or from PI.