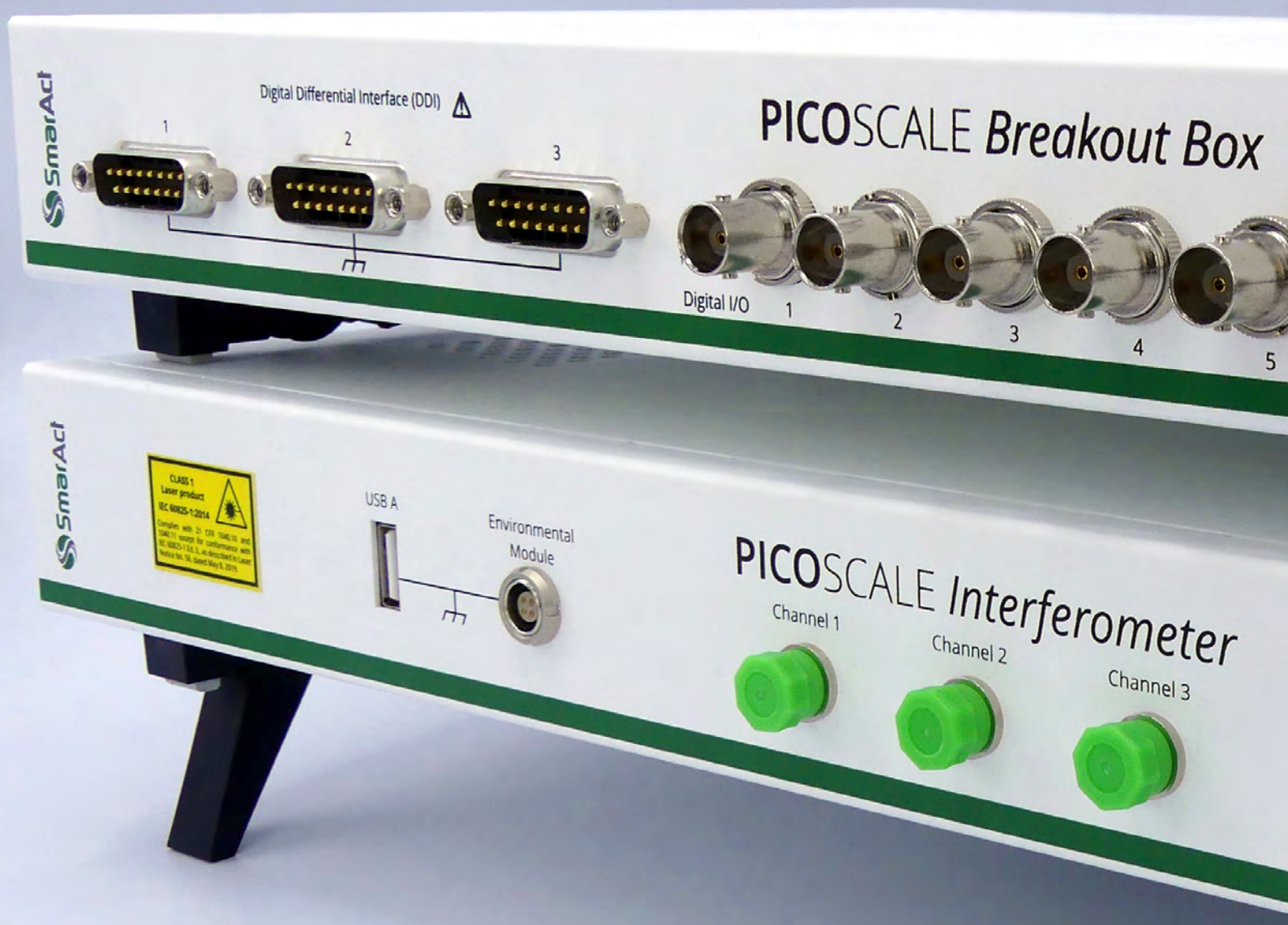
PICOSCALE

Interferometer

SmarAct | metrology

HIGH PRECISION DISPLACEMENT MEASUREMENTS WITH THE **PICO**SCALE *INTERFEROMETER*

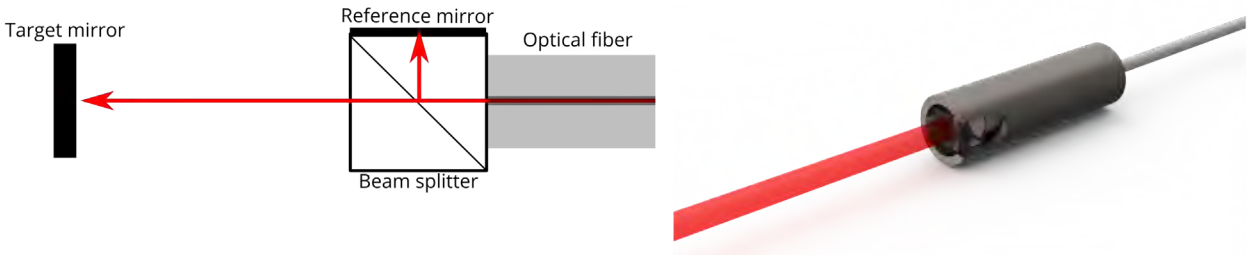


- 3 parallel laser interferometers in one instrument for 3D measurements
- Measurement bandwidth up to 2.9 MHz (10 MHz data rate) with a resolution down to 1 pm
- Measurements possible on various materials (mirrors, retro-reflectors, plastic, glass, metal and even water)
- Wide range of sensor heads available for different applications and environments (including use in vacuum and cryogenics)
- Proven performance with many satisfied customers


Analog output (DACs)
Output 50 Ω
Analog input (ADCs)
1
2
3
6
1
2
1
2
3
Channel
Status
Laser
Status
PILOT

System Components

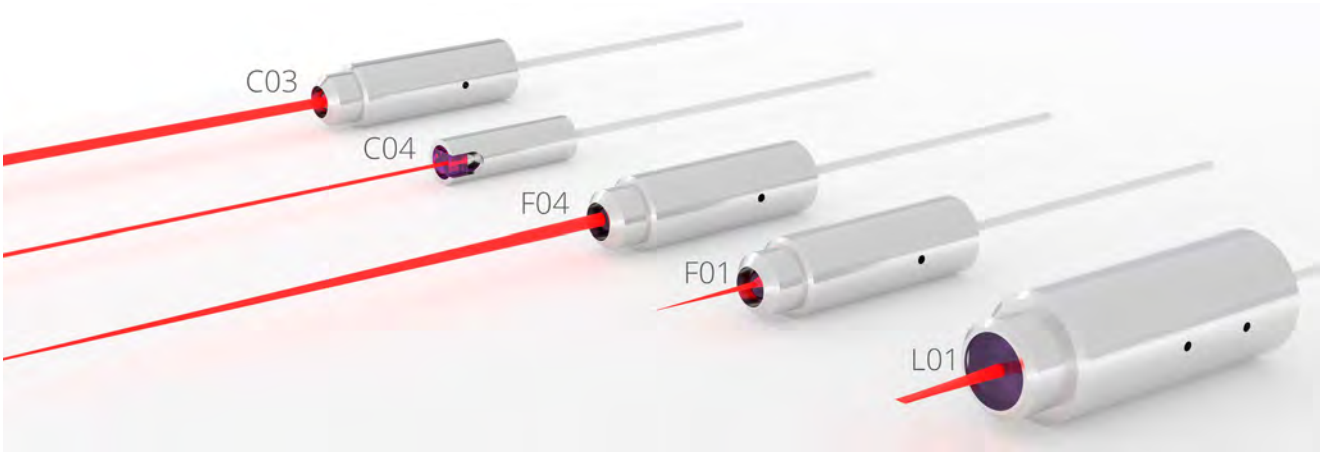
Compact Michelson Interferometer



Key Specifications	
Channels	3
Maximum Target Velocity [m/s]	1
Maximum Working Distance [m]	5
Maximum Data Rate [MHz]*	10
Noise**	1 pm/√Hz @ 1 kHz RMS: 190 pm (band 1 Hz ... 10 kHz)
Target Reflectivity*** [%]	4 - 100
Laser Wavelength**** [nm]	1550 Laser class 1 (eye-safe) Visible pilot laser to assist initial alignment
Measurement conditions	Ambient, ultra-high vacuum, cryogenics
Controller Chassis	48.2 x 32.6 x 6.0 cm, weight 3.7 kg

All **PICO**SCALE products utilize a Michelson interferometer, which operates by splitting a light beam into two paths using a beam splitter. The beams are then reflected off mirrors and recombined, creating an interference pattern. Variations in the optical path length—caused by displacement of the target mirror—modify the interference fringes, enabling precise measurements of picometer-scale position changes.

* *Maximum bandwidth of position data is 2.9 MHz*
** *Working distance 20 mm, ambient conditions*
*** *Not crucial because of Michelson interferometer principle*
**** *Stabilized with gas absorption cell, NIST traceable*



- C03: Collimated measurement beam for large working distance
- C04: Compact sensor head for general purpose
- F04: Focused beam with high angular working range
- F01: Focused beam with high angular working range for small samples
- L01: Line-focused beam for runout measurements of cylindrical targets

	C03	C04	F04*	F01	L01*
Beam Geometry	Collimated		Focused		Line-focused
Focal Distance [mm]	--		70 (customizable)	10 (customizable)	30 or 50
Beam Waist Diameter [µm]	1590	350	100 **	28 *	50 x 1590
Working Distance [mm]	13 ... 5000	13 ... 500	70 ± 10 **	10 ± 0.5 **	± 10
Angular Working Range [°]	± 0.013	± 0.075	± 0.75 **	± 2 *	± 1.3 along focused axis
Environmental Compatibility	Air, HV, UHV				
Typical Targets	Mirror, Retro-Reflector	Mirror	Small Samples, Mirror		Cylindrical Samples
Dimensions [mm]	6 x 21 (Ø x L)	4 x 13 (Ø x L)	6 x 21 (Ø x L)		9 x 26 (Ø x L)

** For a sensor head with 10 mm focal distance*

*** For a sensor head with 70 mm focal distance*

> *We are using a **PICO**SCALE line focusing sensor head to track the motion of a polished cylinder in our synchrotron beamline. This allows us to close a feedback loop and rotate the cylinder without eccentricity or – thanks to the large tolerances of the sensor heads – with a stub offset.*
>
> **- National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan**

PICOSCALE Controller with accessory components: Breakout Box for convenient access to digital and analog signals.

Interfaces

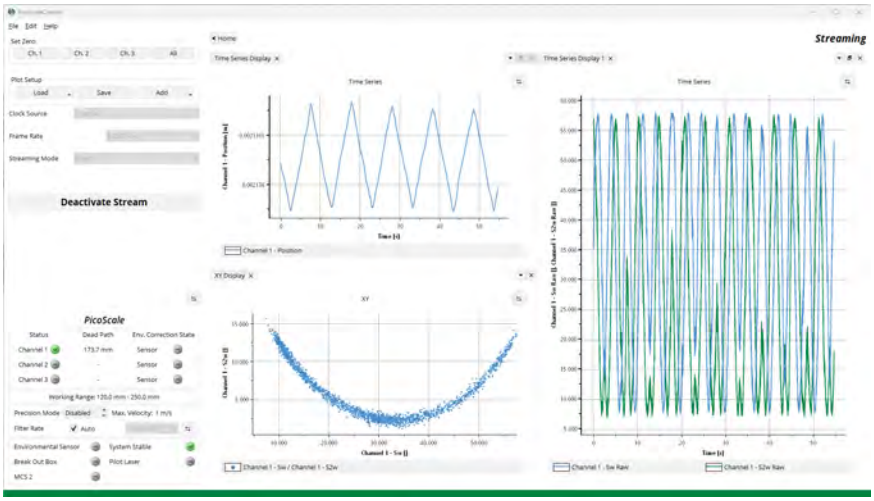
	Key Specifications	
PICOSCALE Controller	**USB and Ethernet**	Data transfer to a user PC with up to 10 MHz data rate.
	Trigger Input	1 Trigger input at rear side
	SmarAct SI Interface	Direct link to SmarAct's motion controllers, e.g. MCS2
PICOSCALE Breakout Box	**Digital Differential Interfaces**	Transmission of displacement calculation system data*
	Analog Input	3 analog-to-digital converters with 16 bit resolution
	Analog Output	3 digital-to-analog converters with up to 16 bit resolution
	Trigger Input / Output	6 digital inputs/outputs for synchronization with external devices
Additional Sensors	**Environmental Module**	Sensors for air pressure, temperature and relative humidity for compensation of changes in the refractive index of air
	Temperature Box	10 channels for resistive temperature sensors (PT1000)

** Available protocols: AQuadB, Serial Data, BiSS-C*

Software

Key Features

- Multi-user ready: simultaneous interaction by a master user and an observer
- Software API with all drivers, libraries and programming examples for customized control software
  - LabVIEW™
  - C/C++
  - Python
- All functions are combined in the convenient graphical user interface “**PICO**SCALE Control”



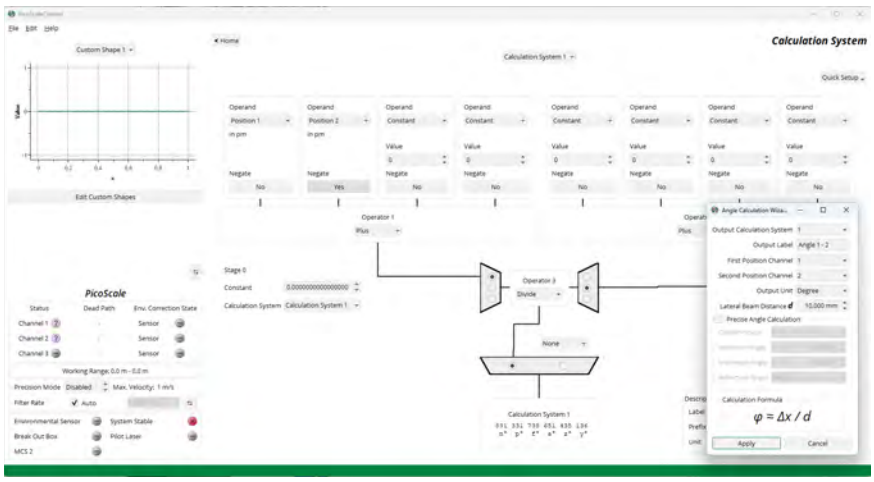
Stream Monitor

- User-friendly options to display and export data
- Spectral analysis using FFT functions
- Streaming data to a file
- Triggered streaming

Advanced Trigger System

- Configuration of triggers for device
- synchronization
- Alerts in case of signal loss
- Event counter
- Clock input/output

> *We are using the* **PICO**SCALE *as a position encoder for our motors and we will integrate the device in our HF facilities soon. We are very happy with the LabVIEW drivers that came with the system that allow us to combine our motion controllers with high precision displacement sensors in a single software tool.*
>
> **- S. Martens, University of Hamburg, Germany**



Calculation System

- Calculation of angles
- Thermal compensation
- Mapping of data with look-up tables
- Other user defined calculations

Real Time Data Processing with Advanced Firmware Modules

The measured interference signals are processed in the **PICO**SCALE field programmable gate array (FPGA) in order to obtain displacement data with stream rates up to 10 MHz. The FPGA can be configured to perform for example real-time angle calculations or lock-in detection.

At Sirius Light Source, in the Brazilian Synchrotron Light Laboratory (LNLS) and the Brazilian Center for Research in Energy and Materials (CNPEM), SmarAct **PICO**SCALE *Interferometer has been used by designers and engineers in several beamline applications over the last five years.*

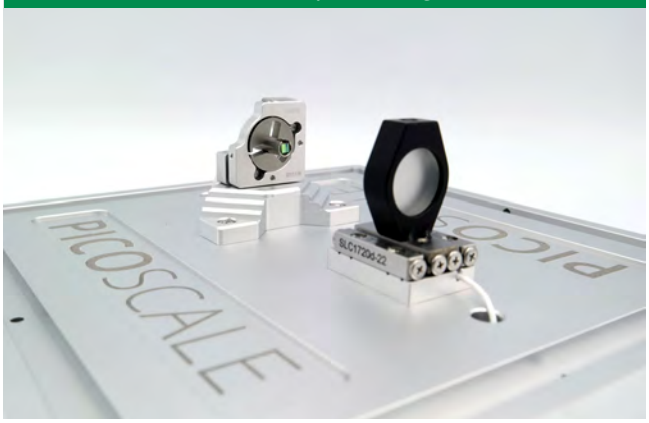
The first case was the High-Dynamic Double Crystal Monochromator (HD-DCM), in which the PicoScale Interferometer is used as an embedded feedback sensor in a high-bandwidth closed-loop control system, allowing for the breakthrough crystal-to-crystals angular stability of 10 nrad RMS (integrated up to 2.5 kHz) both in fixed-energy and flyscan operation modes. The main reason for the choice was the combination of high resolution and high feedback rates with convenient volume claims for the heads and for the optical fibers. Yet, the complete software interface, allowing us to debug and optimize operation, was essential to achieve the final performance.

Moreover, the SmarAct development and support teams were always promptly available to help, from simple questions to specific development needs. From this successful collaboration, **PICO**SCALE *has now been chosen for many other applications in our new 4th-generation synchrotron facility, particularly as metrology items in the most recent microprobe and nanoprobe end-stations.*

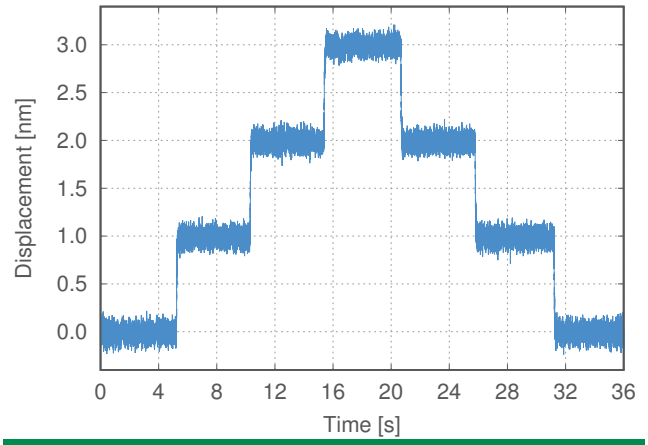
- Ricardo Caliari and Renan Ramalho Geraldes,
Brazilian Synchrotron Light Laboratory (LNLS), Campina, São Paolo, Brazil

Application Examples

Closed-Loop Positioning

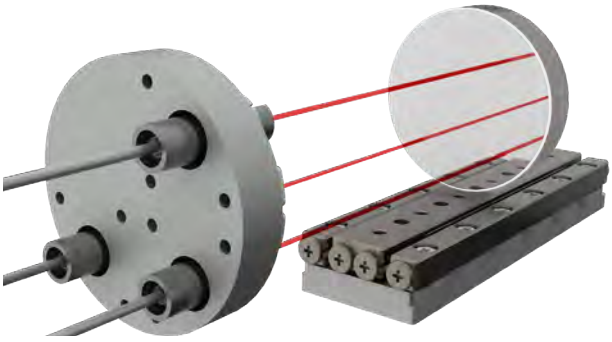


- Displacement encoding with measurement directly at the point of interest
- Low-latency feedback control with direct link between **PICO**SCALE and **MCS**2 motion controller

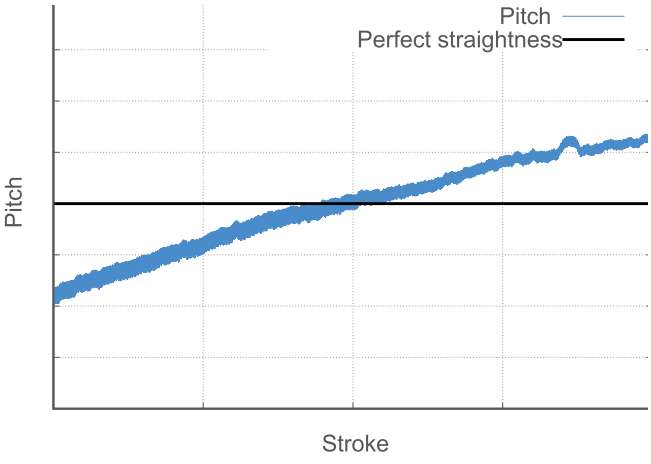


Closed-loop positioning in 1 nm steps using the PICOSCALE Interferometer with a direct link to SmarAct's motion controller MCS2.

Quality Control of Translation Stages

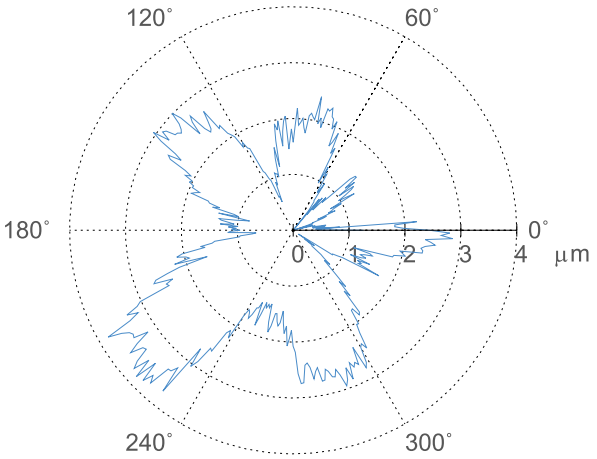


- Simultaneous measurement with 3 channels
- Compact and light sensor heads and targets
- Fast angle calculation in the system's FPGA
- Analysis of translation stages in 3D (z, Rx/yaw, Ry/pitch)



Exemplary pitch measurement of a translation stage over its entire travel range.

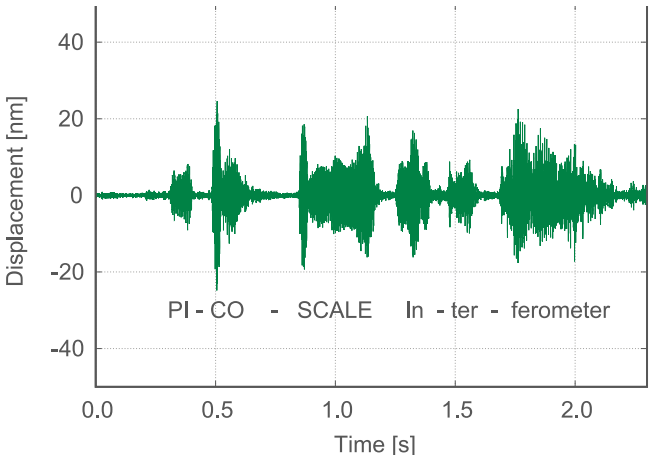
Radial Runout Measurement of a Rotating Cylinder



Radial runout of a rotating cylinder. This information can be used to control the center of rotation.

- Line focusing sensor heads aligned with rotating cylinder
- Measurements of radial runout and wobble
- Large tolerance to stub-offsets
- Sample positioning in synchrotron beamlines

Measurement on a Glass Window



*Sound waves of a human voice excited the glass window and the displacement is measured with the **PICO**SCALE Interferometer.*

- Focusing sensor head directed at a glass window
- Direct streaming of position data into a file for subsequent data processing

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SmarAct Metrology GmbH & Co. KG develops sophisticated equipment to serve high accuracy positioning and metrology applications in research and industry within fields such as optics, semiconductors and life sciences. Our broad product portfolio – from miniaturized interferometers and optical encoders for displacement measurements to powerful electrical nanoprobers for the characterization of smallest semiconductor technology nodes – is completed by turnkey scanning microscopes which can be used in vacuum, cryogenic or other harsh environments.

We maintain the complete production in house for a high level of customization so that we can always provide you the optimal individual or OEM solution. We also offer feasibility studies, measurement services and comprehensive support to accompany you along your projects.

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