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FPS Sensors

Real-Time Interferometric Displacement Analysis

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attoSENSORICS
Ultra Precision Sensors

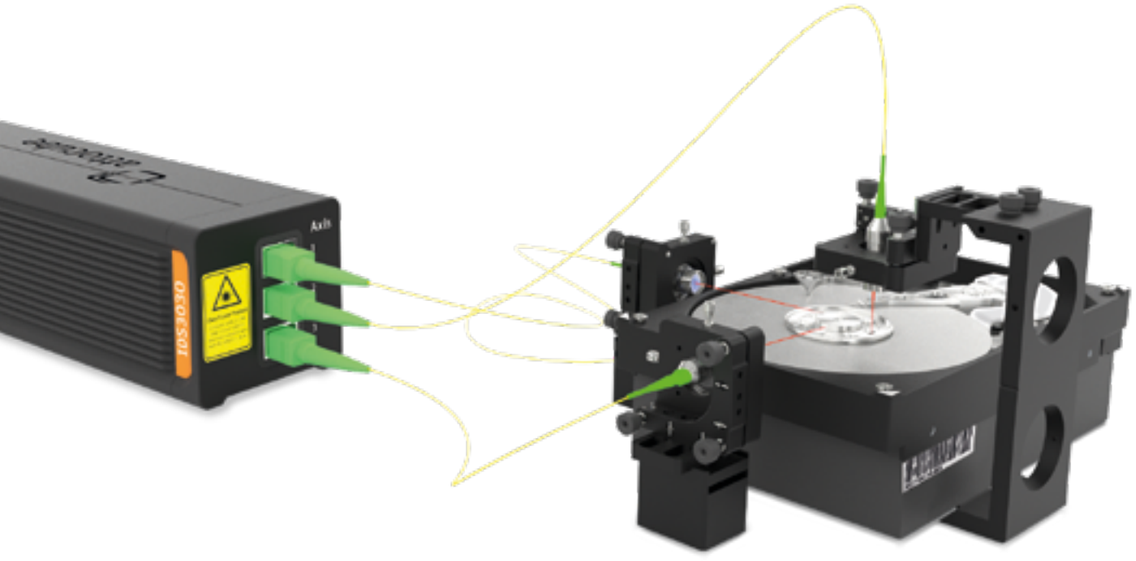
attoSENSORICS: products for nanometer applications

product overview

attocube's innovative optical displacement sensors surpass the performance of other presently available devices in terms of precision, speed, and compactness. The patented fiber-based, interferometric measurement principle offers unrivalled accuracy and stability, while the compact design enables strikingly simple adjustment even in spatially confined setups. Fiber-based sensor heads enable the operation in extreme environments, such as ultra high vacuum, cryogenic temperatures, or even hard radiation.

Two product lines have been established and adapted to perfectly meet existing market demands: The FPS Sensor offers integrated measurement and analysis capabilities and is the perfect choice for contactless, ultra-high precision displacement measurements with immediate data inspection. Typical fields of applications range from quality assurance to R&D. In contrast, the IDS Sensor is ideally suited for machine integration and seamless connection to common industrial networks.

A list of suitable applications for attocube's sensor products can be found to the right.



MACHINE-INTEGRATION

IDS Series

R&D-SETUP

FPS Series

	Integrative Measurement Module	Plug&Play Sensing for R&D-Setups
device chassis	compact case for inline measurements	tabletop/19"rack-mount for laboratory usage
trigger option	BiSS-C interface (optional)	data marking (optional)
analysis software	WAVE (optional)	Daisy (included)
realtime FFT-analysis	WAVE (optional)	Daisy (included)
suitable measurement setups	similar measurement setups	alternating measurement setups
applicable number of axes	high	low
software features	zoom in/out for past data, csv-export of measurement data	angle measurement (pitch/yaw/roll) (optional)
output interfaces	Ethernet, HSSL, AquadB, Sin/cos, linear analog, BiSS-C (optional)	USB, AquadB, HSSL, Ethernet EPICS (optional)

Glossary

attoSENSORICS technical terms

Fabry-Pérot Interferometer

Our FPS and IDS Sensor Systems rely on a low-finesse fiber-based Fabry-Perot Interferometer. A great advantage of this technology over other displacement sensing techniques is their electronic-free sensor heads. The physical dimension of the sensor head is reduced to the millimeter range. This miniaturization makes the sensor ultra-compact and also compatible with extreme environments such as ultra high vacuum and low temperature.

The fiber-based design allows flexible alignment, thus making multiaxis measurements and large distances of fiber length (even covering kilometer long distances) an easy task.

Environmental Compensation Unit (ECU)

The ECU provides a fully automated refractive index compensation for contactless interferometric measurements at ambient conditions. Variations in air pressure, temperature, and humidity are recorded and used to automatically compensate for changes in the refractive index.

Focusing Sensor Head

The focusing sensor heads D4/F17 (sensor head diameter of 4 mm with a focal length of 17 mm), M12/F40, and D12/F2.8 are suitable to measure on a wide range of target materials as well as target surface qualities with low, medium, or high surface reflectivity. For example, the focusing sensor heads make it possible to measure on a BK7 glass object with a reflectivity of only 4 %. The sensor head M15.5/F40 includes a flexure structure to adjust the beam path angle with ±1°.

Collimating Sensor Head

The sensor head M12/C7.6 (sensor head with a M12 metric thread and a beam diameter of 7.6 mm) is suited with a collimating optics type especially designed for the use with retroreflectors. It is optimized to measure over longer distances.

Working Distance

Distance between the front side of the sensor head and the target where a continuous measurement is possible.

Absolute Distance

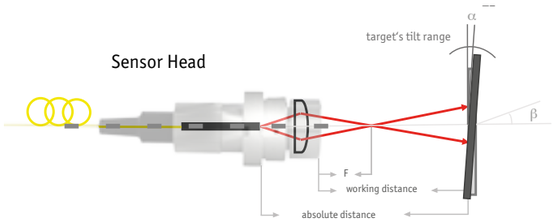
Distance between the end of the fiber, which is represented by the mechanical stop, and the target.

Focal Length

The focal length F is the distance between the front side of the sensor head and the focal point.

Alignment Tolerance

The angular alignment tolerance represents the target's tilt range in respect to the laser beam (α in the figure below). The laser beam might not be parallel to the central axis of the sensor head (β in the figure below). At retroreflectors, the center of roration is defined as the center of the retroreflector.

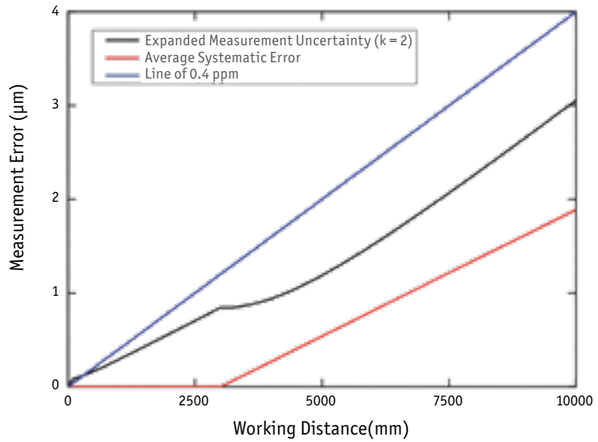


PTB-Certification for Interferometers

highest accuracy over long distances

Attocube's interferometers have been tested by the National Metrology Institute of Germany (PTB). The accuracy of the interferometers has been confirmed at various pressure, humidity and temperature conditions over several days, thus also confirming the high performance and reliability of attocube's ECU (environmental compensation unit).

The IDS was checked over a working distance of 10 meters. The systematic error of measurement was quantified to 0.0 ppm between a working distance of 0 m and 3 m. The total expanded measurement uncertainty (k=2), consisting of the systematic and random measurement errors mostly remains under 0.4 ppm.



The figure above shows the systematic measurement error and the measurement uncertainty of the IDS as certified by the PTB. They depend on the working distance. The blue line represents a measurement error of 0.4 ppm that surrounds the other lines, while the average systematic error is always lower than 0.19 ppm.

Download the calibration certificate for the IDS/FPS at our website:

IDS certificate

FPS certificate

FPS Sensors

plug&play sensing for R&D-setups

The global trend towards miniaturization causes major challenges for advanced metrology: quality standards are increasing, requirements on accuracy and reliability are constantly rising, and failure tolerances in production processes are steadily reduced. Especially in applications such as quality assurance and research & development, instruments need to provide highest precision, while offering versatile implementation options and the immediate availability of data post-processing, analysis, and storage.

With its advanced software automation, the FPS displacement and analysis system is the perfect solution for contactless, ultra-high precision and non-invasive displacement measurement tasks requiring immediate data inspection. Its plug-and-play architecture enables direct integration and versatile operation in a variety of applications within only few minutes.

Accurate

The built-in DFB laser of the FPS is locked to a molecular absorption frequency reference, making the detected displacement traceable to international length standards. All measurements are therefore truly accurate in a metrological sense. (see page 199)

Radiation hard

Optional radiation-hard sensor heads and fiber packages are available for the operation in radiation harsh environments. All radiation-hard (/RAD) components are qualified for radiation doses of up to 10 MGy.

Ultra fast

All FPS sensors measure the position of the target with a bandwidth of 10 MHz and a resolution of 1 pm. At the same time, the sensor is compatible with displacement velocities of up to 1 m/s.

Multi axis operation up to 2 m

The FPS provides three measurement axes, allowing parallel displacement measurements of three targets in real-time. This enables economic measurements in a nanometer range.

Dedicated software Daisy

FPS sensors are delivered with a dedicated PC-based software, allowing synchronous data visualization, analysis, and storage.

Environmental compensation

FPS sensors can be equipped with an optional environmental compensation unit (ECU). The ECU enables the operation of FPS sensors at ambient conditions, while maintaining an accuracy of better ± 1 ppm under a wide range of pressure, temperature, and humidity conditions.

PC & real-time interfaces

Built in USB 2.0 and Ethernet (optional) interfaces enable plug-and-play communication with any personal computer. High-speed real-time interfaces further broaden the application spectrum of the FPS.

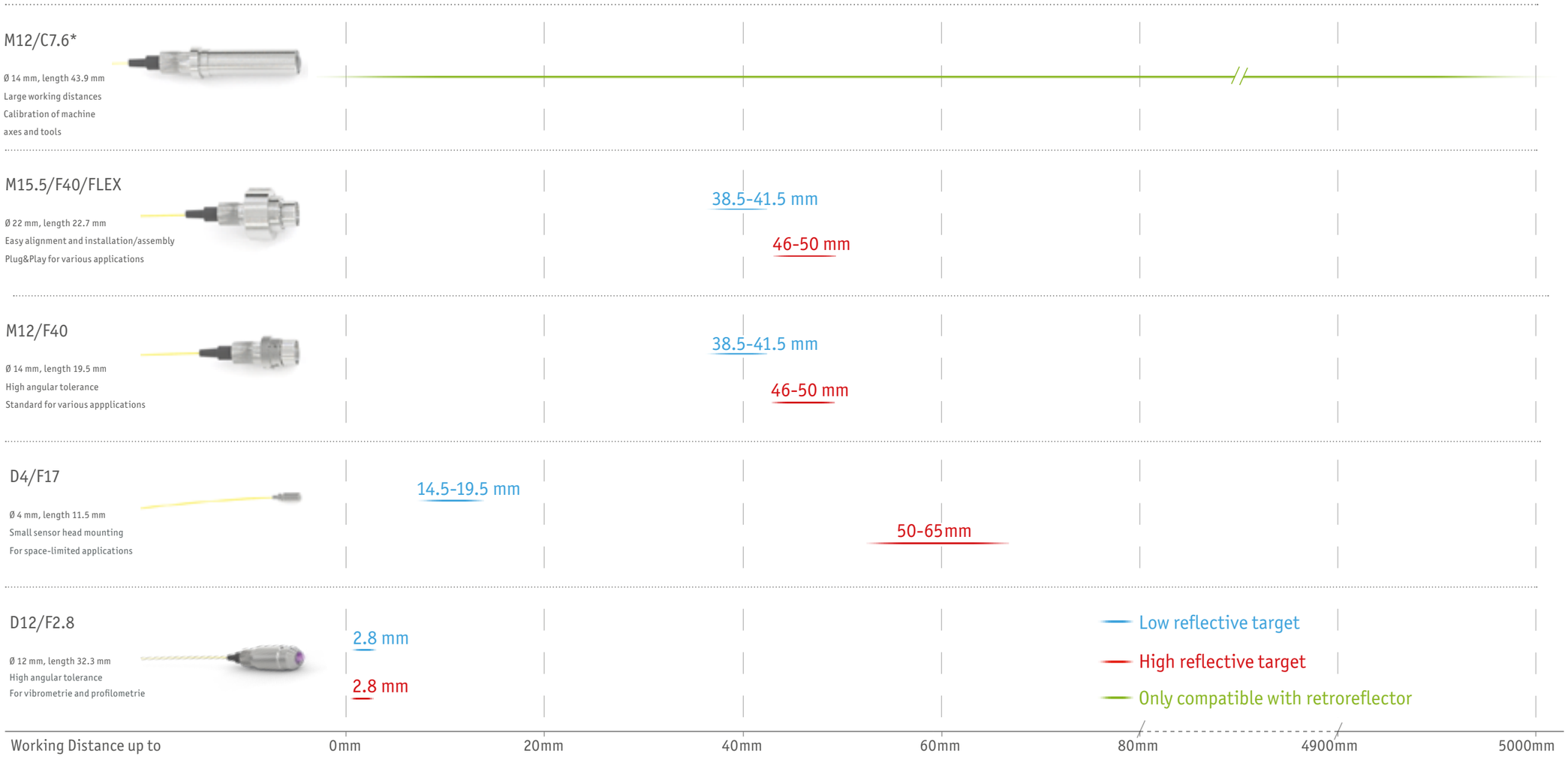
Contactless & miniature

Using small-sized sensor heads, the FPS suits space-limited applications. The technology is based on the Fabry-Pérot interferometer that enables contactless measurements and is resistant to outside influences.

Sensor Head Overview

IDS & FPS

The IDS and FPS can be operated with different sensor heads: ultra compact heads for the most confined spaces or alternative designs where priority is given to easy alignment or to the compatibility with various target materials (glass, aluminum, ceramic, etc.).



*FPSH: 0..2000 mm; IDSH: 0..5000 mm
[1] By using special sensor heads, the IDS can realize measurement distances of up to 30 meters.

attoSENSORICS

FPS3010 & FPS1010

table-top displacement sensing

attocube's FPS3010/1010 is a fully automated interferometric displacement measurement system, compatible with up to three fiber-based sensor heads. TheFPS3010/1010 combines state of the art hardware with innovative software concepts, offering real-time data processing and storage, Fast-Fourier signal analysis for vibrometry applications, environmental index of refraction compensation (optional), and many other measurement options such as angular measurement software or customized trigger functionality. The flexible, FPGA-based architecture allows firmware upgrades at ease, ensuring that newest features and updates are available to users world wide. Real-time serial-word and incremental interfaces allow the connection of FPS3010 and FPS1010 devices with other electronics and host controllers.

19"rack-mount version

For electrical cabinets used at research lab, a 19" version is available upon request

Environmental compensation unit – ECU

The environmental compensation unit enables sub-ppm accuracy in ambient conditions see page 20

Angluar measurement software - AMS

The angular measurement software enables real-time angular measurements with stunning resolution see page 22

CUSTOMER FEEDBACK

Prof. Dr. M. Tajmar

The noise and stability of the attocube FPS interferometer is up to two orders of magnitude better than the second best system on the market. The installation and use of the sensor was so easy that we could obtain high quality measurements within two weeks after they first arrived at our lab – thanks to the great support from attocube.

(Institute for Aerospace Engineering, Dresden University of Technology, Germany)

CUSTOMER FEEDBACK

Dipl.-Ing. Nanxi Kong

The motion of a feed unit for micro manufacturing needs to be very precise and accurate. As linear encoders allow only the measurement of the position along one axis, the attocube FPS interferometer can be easily configured to directly measure the position of the tool center point at the feed unit in all directions.

(Institute of Production Engineering, Helmut Schmidt University, Hamburg Germany)

Fields of Applications

Metrology

Microscopy

Semiconductor Research

Synchrotron

Machine & Tool Vibration Analysis

Space Applications

Sensor	
number of sensor axes	1 or 3, upgradeable[1]
working distance	0...2000 mm
sensor resolution	1 pm
sensor repeatability	2 nm[2]
max. target velocity	1 m/s
measurement bandwidth	10 MHz
signal stability (WD: 20 mm)	0.286 nm (2σ)
Modes of Operation	
remote operation	USB2.0, ethernet port optional
output signal: electronics	USB, ethernet[3], AquadB, HSSL
output signal: displacement measurement	laser light
sensor alignment	semi-automated via USB
sensor initialization	fully automated, turnkey
Interfaces	
digital interfaces	AquadB, HSSL (real-time)
Controller Hardware	
chassis	21.4 x 21.4 x 4.5 cm³
weight	1.9 kg
power supply	100/115/230 V, 50..60 Hz
power consumption	max. 100 W
Measurement Laser	
laser source	DFB laser (class 1)
laser power	150 µW
laser wavelength	1530 nm
wavelength stability	50 ppb

1) The FPS1010 can be software-upgraded from one to two and three axis, respectively.
2) At 10 mm working distance (WD), 5 nm repeatability at 100 mm WD, in vacuum conditions.
3) upgrade option /SYNC.

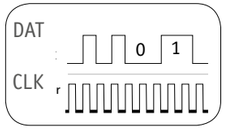
FPS Sensors – Interfaces

real-time connectivity

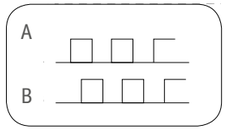
FPS sensors are designed for ease of use and simple connectivity. Measured displacement information can be transferred to a personal computer using USB or Ethernet (optional), where the measurement software Daisy allows synchronous data visualization, analysis, and storage. In addition to these standard interfaces, the FPS includes the high-speed real-time digital interfaces AquadB and HSSL.

① Main Power
② Ethernet (optional)
③ Serial
④ USB 2.0
⑤ GPIO (General Purpose Input/Output)
⑥ HSSL / AquadB

Interface Specifications					
target velocity [m/s]	0.0001	0.001	0.01	0.1	1
resolution USB (abs.) 64 bit, 100 kHz [nm]	0.001	0.001	0.001	0.001	0.001
resolution HSSL (abs.) 8-48 bit, up to 25 MHz [nm]	0.001	0.001	0.001	0.001	0.001
resolution AquadB (inc.) at 25 MHz [nm]	0.004	0.04	0.4	4	40



HSSL (digital; bandwith up to 25 MHz and 8-48 bit resolution): attocube's proprietary serial word protocol provides absolute position information. The HSSL interface consists of two signals (single ended or differential): the clock signal and the data signal that includes the position information.



AquadB (digital; bandwith up to 25 MHz; resolution freely assignable): The AquadB interface provides incremental displacement information on target displacement. Position resolution and (maximum) clock rate can be user defined using the software interface.

Daisy: FPS Measurement Software

visualization and analysis of measurement data

The completely new PC-based software of the attocube FPS sensor system not only enables simple data recording. Instead, it offers a ton of features making complex measurements simple - ranging from easy-to-use sensor alignment to synchronous data storage, data marking, and fast-fourier transformation.

① Synchronous Data Visualization

The FPS software "Daisy" allows the user to choose a common time base for all axes displayed in order to show displacement data synchronously.

② Synchronous Data Storage

Position data of all three axes can be saved into one common file with a word length of 64 bits for each axis.

③ Dynamic Link Libraries & Virtual Instruments

With the included DLL and LabVIEW VI's, all features of the PC software can be accessed through C/C++/C# and LabView.

④ Real-Time FFT Analysis

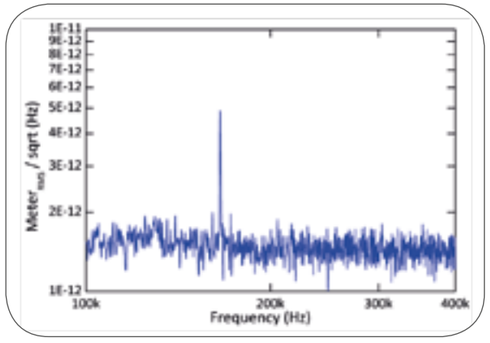
The real-time Fast-Fourier-Transformation allows a live vibration analysis.

⑤ Data Marking for Triggering Data Acquisition

The optional feature for data marking includes the function to use external trigger for marking measurement data.

⑥ Improved Initialization Routine

The software package includes reinitialization of system parameters during ongoing measurements, significantly increasing alignment tolerances of sensor heads.

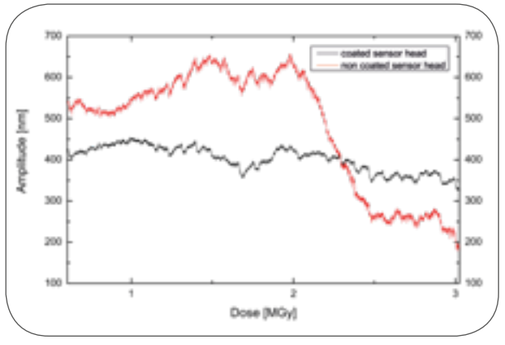


The shown plot depicts the fast Fourier transform (FFT) analysis between 100 and 400 kHz of a commercial cantilever. The cantilever under investigation has the following dimensions: 225 µm x 38 µm x 7 µm (L x W x T). The resonant frequencies of this cantilever can be seen at 165.6 kHz and the noise floor in the presented frequency range is around 2 pmRMS / sqrt(Hz).

Measuring Brownian Motion of Commercial Micro-Cantilevers

The resolution capability of the IDS was demonstrated by measuring the Brownian motion of micro cantilevers. Measuring the tiny vibrations of objects excited only by its thermal energy is typically challenging the resolution capabilities of a measurement system. The cantilever was placed on attocube positioners and measured with the focusing sensor head (D12/F2.8). This sensor head has a shot diameter of smaller 2 µm. The figure clearly shows an individual resonance peak at 165.6 kHz excited due to Brownian motion.

(attocube application note SEN15, 2016)



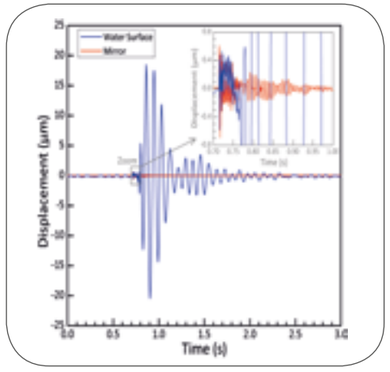
The figure shows the measured positions while the sampling rate of the encoder positions was set to 1 kHz. The position drift observed over the full period of 34 days and a cumulated dose of 3 MGy was only 150 nm with the coated sensor head and 400 nm with the uncoated one.

Radiation Harsh Environments

The FPS3010 can operate under extreme radiation opening ways to use interferometric systems and subsystems close to synchrotron beams and beamlines, or other environments with high radiation.
An experiement conducted under irradiation from a 60Co source (1.17 MeV / 1.33 MeV γ- and 0.31 MeV β-rays) shows the stability concerning radiation harsh environments of attocube's sensor heads. The FPS3010 controller was placed outside the chamber and located in a temperature controlled chamber located in a nonradioactive zone. The temperature stability inside the chamber was better than 1°C during the complete measurement cycle. The total cumulated dose at the end of the measurement was 3.024 MGy in water equivalent. The setup and installation were proven to be robust in terms of mechanical vibration, giving a position uncertainty of less than 10 nm over a measurement period of 34 days. The measured positions were stable within a few 100nm during the whole time.

(attocube application note SEN10, 2014)

Selected Applications
FPS Sensors

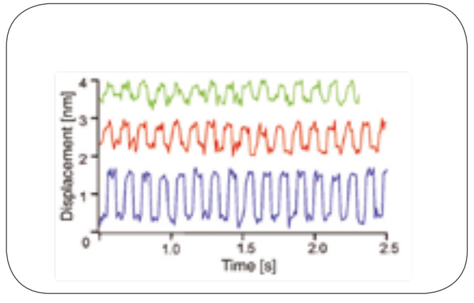


The blue curve shows the water surface and sensor head movements and the red curve represents the displacements measured on the side of the mirror after hitting the optical table with a hammer.

Measuring Water Surface Displacements

To measure the displacements of a cup's water surface compared to the displacements of the table the cup is positioned on, two focused sensor heads were used: one of them focused on the water surface, the other focused on a mirror fixed to the table, while the table was hit by a hammer. The water surface oscillates with a maximum deflection of approximately ± 20 µm and the table oscillates with a maximum amplitude of around ± 0.7µm. The zoom highlights that the two measurement arms show similar behaviors in the high frequency range for the first milliseconds after the excitation.

(attocube application note SEN16, 2017)



300 pm, 500 pm, and 1000 pm steps performed by the scanner in the z-direction and recorded by the fiber-optic interferometer. Interferometer head-reflector separation was set to 25 mm.

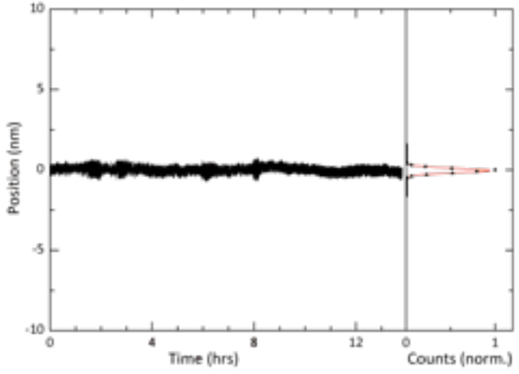
High Resolution X-Ray Microscopy

When developing an X-Ray microscope capable of nm resolution, careful design is a must. Thermal and mechanical stability of the components and assemblies has to be followed throughout the process. The FPS shows superior performance regarding its outstanding stability and its capability of measuring sub-nm displacements. The senor has a better than 1.25 nm stability over 40 hours, and a better then 300 pm resolution at 100 Hz bandwidth in a controlled environment. The FPS is therefore the ideal supplement for the mechanical control of all components used in the described X-Ray microscope setup achieving a resolution in the order of 40 nm, while the stability is below 45 nm over the entire time needed for data collection.

(attocube application note SEN09, 2014)

Selected Measurements

unsurpassed signal stability



Measured Long-Term Signal Stability	
working distance [mm]	2σ [nm]
20	0.286
50	0.530
100	1.035
Measured Short-Term Signal Stability	
working distance [mm]	2σ [nm]
30	0.039

Long-term FPS signal stability as demonstrated on a 20 mm long Titanium vacuum reference cavity. The cavity is cooled to liquid helium temperature (-269 °C) in order to minimize thermal expansion/contraction. 68% of all position measurement data points lie within 286 pm, as measured at a 100 Hz bandwidth over 12 hrs. Short -term data are recorded at 10 Hz over 10 seconds.

Long-term picometer stability

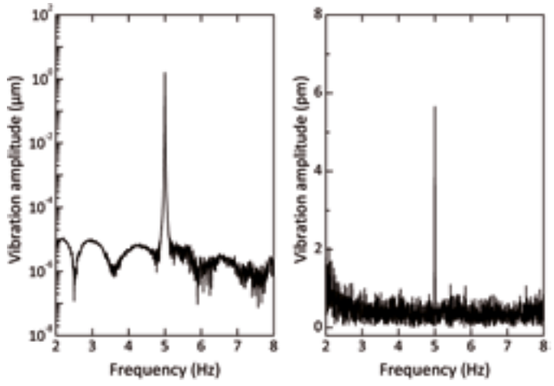
The intrinsic position signal stability of the FPS sensor is unsurpassed - making it challenging to demonstrate the performance of FPS sensors with standard tools and equipment. The measurements shown above were therefore recorded on an evacuated reference cavity with a relative length stability $\Delta l/l$ well below 10^{-8}. This stability was achieved by temperature stabilizing the titanium cavity within few mK at liquid helium temperature (-269 °C).

Due to the low coefficient of thermal expansion at said temperature, the titanium cavity provides a reference in length approximately 10 times more stable than a corresponding ultra-low-expansion glass (ULE) cavity at ambient conditions. The plot shows position sensing data recorded on a 20 mm long cavity during a 12 hour period of time. The bandwidth of the measurement was 100 Hz.

(attocube applications labs, 2012)

Selected Measurements

real-time vibrometry measurements



Vibrometry measurements as performed on a piezoelectric ceramic, measured with a FPS sensor. Stunningly, vibration amplitudes of few picometers can be detected even at low frequency.

Ultra-wide frequency range vibrometry

The FPS sensor is not only a very capable real-time displacement sensor but it also serves the user as a powerful vibrometer. With its built-in fast-Fourier algorithm (FFT), the FPS series directly detects the distribution of vibrational modes/amplitudes in frequency space. Frequency and phase information of resonance peaks can be live-viewed on the PC-based FPS application software. The data above demonstrate the suitability of the FPS sensor for this type of application. In this specific case, the low-frequency noise behaviour of the FPS sensor was tested by exciting and measuring the vibration spectrum of a ceramic piezo at low frequency and ultra-low amplitude. As can be seen from the data, the noise floor of the measurement is at 10^{-6} microns equivalent to 1 picometer. Stunningly, this noise floor extends to very low frequency, enabling picometer resolution at frequencies as low as 2 Hz. Data are recorded at 100 Hz bandwidth.

(attocube applications labs, 2014)

Sensor Head Specifications

IDS & FPS

Sensor Heads						
product name	D12/F2.8	D4/F17		M12/F40	M15.5/F40/FLEX	M12/C7.6
Modes of Operation						
optics type	focusing	focusing		focusing	focusing	collimating
dimensions	Ø 12 mm, length 32.3 mm	Ø 4 mm, length 11.5 mm		Ø 14 mm, length 19.5 mm	Ø 22 mm, length 22.7 mm	Ø 14 mm, length 49.2 mm
mounting	clamped	clamped		metric M12 x 0.5	metric M15.5 x 0.5	metric M12 x 0.5
focal length	2.8 mm	17 mm		40 mm	40 mm	infinity
connector	FC/PC	fiber glued		FC/PC	FC/PC	FC/PC
working environment	/RT, /LT/HV, /UHV, /RAD				/RT, /LT/HV, /UHV, /RAD	
benefits	short distance and wide angle	lower surface quality		broad variety of applications	easy to mount and easy to align	long distances and working ranges
exemplary applications	vibrometrie and profilometrie of various geometrical shapes	deformation monitoring of work pieces during manufacturing		concentricity tests, detection of imbalances	monitoring and diagnostics of machine tools components	calibration and synchronization of large-scale machine tools or coordinate measurement machines
Measurement Specifications						
working range (target: glass)	2.8 mm ± 4 µm	14.5..19.5 mm		38.5..41.5 mm	38.5..41.5 mm	-
alignment tolerance (target: glass)	± 4°	± 0.15°		± 0.35°	± 0.35°	-
working range (target: mirror)	2.8 mm ± 20 µm	50..65 mm		46..50 mm	46..50 mm	-
alignment tolerance (target: mirror)	± 10°	± 0.2°		± 0.35°	± 0.35°	-
working range (target: retroreflector)	-	-		-	-	up to 5000 mm
alignment tolerance (target: retroreflector)	-	-		-	-	± 15 °
lateral alignment tolerance (target: retroreflector)	-	-		-	-	± 2 mm
						

Compatible environments

/RT (ambient conditions):	0 .. 100 °C, 1x10^{-6} mbar .. 10 bar	/LT (low temperature):	mK .. 423 K (150 °C 1x10^{-6} mbar .. 10 bar
/HV (high vacuum):	0 .. 150 °C, 1x10^{-8} mbar .. 10 bar	/RAD (radiation hard):	0 .. 150 °C, up to 10 MGy radiation dose
/UHV (ultra high vacuum):	0 .. 150 °C, 1x10^{-10} mbar .. 10 bar		

Naming Scheme

F40:	focussing head with 40 mm focal length	D4:	4 mm mounting diameter
C7.6:	collimating head with 7.6 mm spot size	M12:	M12 x 0.5 metric thread mounting
FLEX:	flexure structure with integrated (theta, phi) adjustment range		

Customized Sensor Heads

Depending on your specific application, modifications concerning the type of optics, focal length, working environment or filter options are possible.

Accessories

optional items for the attoSENSORICS product line

Accurate interferometrical measurements in ambient environment

In order to reduce position inaccuracy due to air-induced variations of the index refraction, attocube supplies an environmental compensation unit (ECU). By locally measuring environmental parameters, an accuracy of typically better ± 1 ppm can be achieved in air. The ECU is plug and-play compatible with all IDS models and can be screw- or magnet mounted.

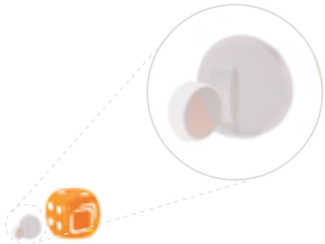
IDS ECU

FPS ECU

Technical Specifications	FPS	IDS
art. no.	1008536	1010698
dimensions	Ø 37 mm, height: 17.4 mm	28 x 61 x 20.5 mm³
weight	36.5 g	41.5 g
integrated sensors	T, p, rH	
interface	GPIO port	RJ12 connector
sensor mount	magnetic mount, screw mount	screw mount
working environment	non condensing	
cable length	2,5 m	1,83 m
Measurement Accuracy (Sensors)		
T-sensor	±0.1°C (0..50°C)	
p-sensor	±1 hPa (300..1100 mbar)	
rH-sensor	±2% (10..90%)	
typ. accuracy setup	better ± 1 ppm	guaranteed ± 1.0 ppm up to 5m; expected ± 0.0 ppm up to 4,2 m

Accessories

optional items for the attoSENSORICS product line



Plane mirrors

Plane mirrors are used in applications were miniature size matters and where vacuum/ low temperature compatibility is key. Available in different sizes.

Recommended sensor heads: D4/F20, M12/F40, M15.5/F40/FLEX

14 days delivery

Article	Art. No.
aluminum mirror Ø 5 mm:	1010847
aluminum mirror Ø 9 mm:	1010846

Retroreflectors

Retroreflectors are used for large dynamic working ranges, such as e.g. in industrial machining applications or in coordinate measurement machines. Working range up to 5000 mm.

Recommended sensor heads: M12/C7.6

14 days delivery

Article	Art. No.
mounted retroreflector:	1010022
unmounted retroreflector /HV:	1013419
unmounted retroreflector /UHV:	1013420

A wide variety of customized targets are available (such as unmounted corner cube retroreflectors, mirrors, or glass targets)

Accessories for FPS

optional items for the attoSENSORICS product line

Angular measurement software upgrade

With the angular measurement software, the FPS can now also be used to non-invasively measure angular position variations with high resolution. The software is set up to handle three customized sensor heads in parallel, displaying two angular and one linear position information. As with the linear measurement software, the angular software outputs position information via USB, AquadB, and HSSL. Specific sensor head holders for angular measurements are available. This feature requires three customized sensor heads with a collimating optics and a beam diameter of 1.6 mm.

Technical Specifications	
number of axes	three - alpha, beta, linear
max. sensor separation	d ≤ 2000 mm
bandwidth	10 MHz (angular & linear)
position output	USB, AquadB, HSSL
Resolution	
angular [1]	10 µ° (170 nrad)
linear	1 pm
Article	**Art. No.**
AMS:	1008537

Range	
angular [2]	±5°
linear	0 .. 2000 mm
Rel. Error	
at 1°	$2x10^{-8}$
at 5°	$5x10^{-5}$
Sensor Head Holders	
M12/C1.6 (customized)	d=40 mm, Art. No. 1008993
M15.5/C1.6/FLEX (customized)	d=40 mm, Art. No. 1008994

[1] depending on measurement range

[2] in software physical range depending on sensor head ±1° typ

2.5 m

BNC 1m

Cables / Wiring Options

HDMI to SubD adapter cable incl. level adaptation: connecting from HDMI to SubD, supplying both differential AquadB, single-ended AquadB, and single-ended HSSL outputs. One adapter cable is required per axis. Compatible with both FPS1010 and FPS3010, output level complies with TTL/LVDS standards. In addition, we supply a SubD to BNC cable with a length of 1 m to get a direct connection to the single-ended AquadB signal via BNC connetors.

Article	Art. No.
2.5 m:	1007329
10 m:	1007332
BNC 1 m:	1007330

Accessories for FPS

optional items for the attoSENSORICS product line

FPS1010 axis upgrade

On-site software upgrade from one to two or one to three axes (no send-in of the unit required). Please inquire at info@attocube.com for upgrade pricing.

Article	Art. No.
axis upgrade:	1007181

SYNC package

Ethernet connectivity including EPICS software drivers, TCP/IP commands, and documentation.

Article	Art. No.
SYNC:	1007182

Optics Kits

There are three different packages available:

"Basic" including an alignment laser (635 nm) and a fiber cleaning tool

"Pro" all "Basic" articles as well as additional kinematic mounts for sensor head (type: M12 & M15.5/FLEX) and mirror adjustment

"Pro xs" all "Basic" articles as well as additional kinematic mounts for sensor head (type: D1.2 & D4) and mirror adjustment

Article	Art. No.
FPS - Optics Kit "Basic"	1010710
FPS - Optics Kit "Pro"	1010711
FPS - Optics Kit "Pro xs"	1010712