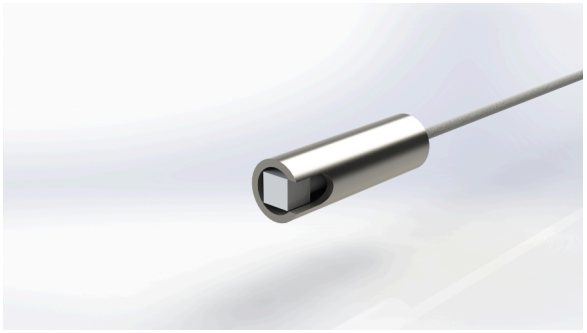
PicoScale sensor head type C01



The C01 is the standard sensor head type for the **PICO**SCALE *Interferometer*. Due to its collimated output beam, the compact form factor and the various customization options, it is appropriate for most common applications.

Table 1. *Summary of optical properties (typical).*

Property	Value
Wavelength	1555 nm
Optical output power	75 µW
Laser output mode	single mode
Beam waist diameter (d_0)	400 µm
Waist position	0
Beam divergence	2.5 mrad
Working distance	13-650 mm
Beam geometry	circular
Angular working range*	±0.05°

*See section 1.3.

1. OPTICAL SPECIFICATIONS

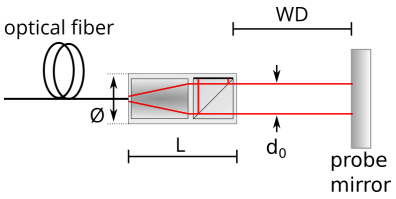


Figure 1. *Schematic drawing of the sensor head C01.*

Each sensor head (see figure 1) is based on two main components: the lens system, collimating the fiber output beam and the beam splitter, which splits the beam into a reference and probe beam. The reference beam is reflected off an internal reference mirror, coated to one side of the beam splitter cube. The probe beam exits the head and is reflected off the target surface in order to track its relative displacement. The front surface of the beam splitter marks the absolute zero position of every **PICO**SCALE measurement as here the probe and reference beam are of equal length.

1.1 Beam properties

The probe beam has its waist approximately at the front surface of the beam splitter cube, where the beam has a diameter of about 400 µm. In the far field of the beam its diameter increases with a slope of 2.5 mrad, as shown in figure 2.

1.2 Working distances (WD)

The **PICO**SCALE sensor head C01 is specified for working distances between 13 and 650 mm. However, due to the inevitable divergence of the laser beam, the optical power collected by the sensor head decreases, if the working distance increases. In figure 3, the optical signal is shown for varying working distances. For the C01, we recommend working distances below 300 mm. Larger working distances are possible, but the signal-to-noise performance will be limited.

1.3 Angular working range

The optimal performance of the sensor head is obtained, if the maximum light intensity returns from the target mirror. This is ensured for normal incidence of the probe beam on the mirror. However, the sensor head still collects some light, if the target mirror is tilted with respect to the beam. Figure 4 shows the angular working range of a C01 sensor head. For the measurement, a target mirror was placed at a working distance of about 50 mm. The sensor head was aligned and the automated optimization routine was performed, generating optimum signal quality. Then, the target mirror was tipped/tilted and the angle at which the **PICO**SCALE recognized a ”beam interrupt” event[1] was recorded. The blue circle indicates the minimum angular working range in all directions, for standard beam interrupt settings.

[1] The **PICO**SCALE controller provides an event notification system and can alert the user in case the signal quality drops below a specified level.

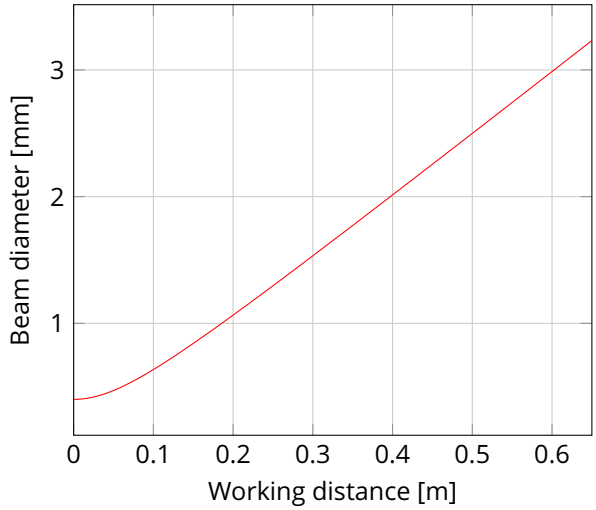


Figure 2. *Beam diameter as function of working distance.*

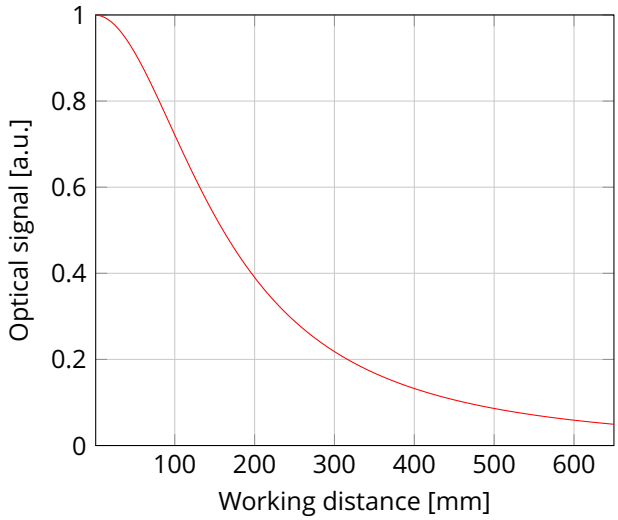


Figure 3. *Optical signal recovered by the sensor head as function of the working distance.*

1.4 Options

The C01 sensor heads can be equipped with different beam splitters, allowing to customize the optical properties.

Reference mirror at the front face

In a standard C01 sensor head the reference mirror is coated to one of the side faces of the beam splitter. In setups with specific space constraints it can be advantageous to use a beam splitter with the reference mirror coated to its front face, so that the probe beam exits the head perpendicularly.

No reference mirror - differential measurements

Generally, the reference mirror is directly coated to the beam splitter. However, sensor heads are available without any reference mirror. In this case, the user has to provide an additional mirror to be used as reference. This setup allows to measure relative displacements of two targets.

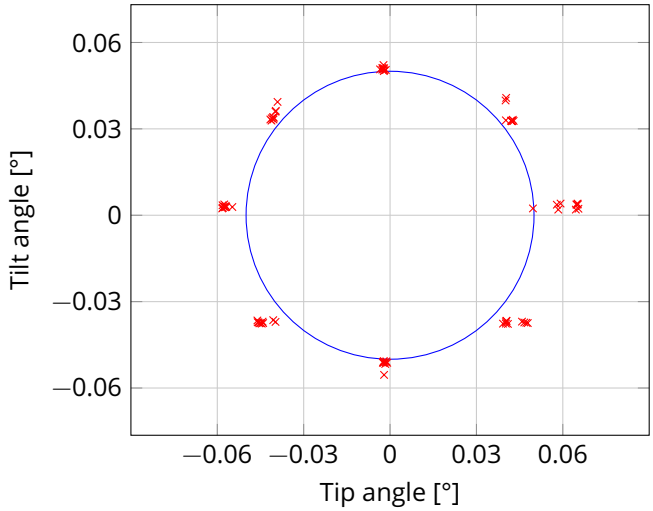


Figure 4. *Angular working range for a sensor head C01 and a target mirror at a distance of 50 mm. The typical minimum angular working range was determined to ±0.05 degrees.*

Beam splitter ratio

In standard sensor heads the laser beam is equally split into the reference and the probe arm. When targets with low reflectivity are used, the signal-to-noise ratio can be increased, if the beam splitter guides more power into the probe beam. Therefore, the beam splitter ratio can be customized.

2. VACUUM COMPATIBILITY

The standard sensor heads are designed to operate in ambient conditions. However, all sensor heads can optionally feature high vacuum, ultra-high vacuum or cryostat compatibility. For the high-vacuum option (-HV), the sensor heads can be used in vacuum conditions with pressures as low as 10^{-6} mbar.

The ultra-high vacuum option (-UHV) is required if the sensor heads are used at pressures as low as 10^{-11} mbar. They are specified for bake-out temperatures of up to 150°C.

For cryostat compatibility (-CRYO), please contact us.

3. HOUSING

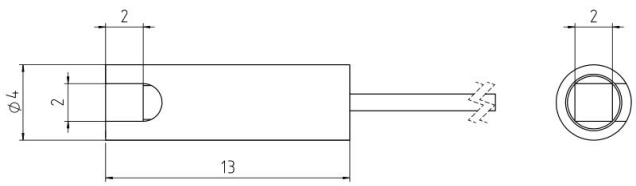


Figure 5. *CAD drawing of the sensor head C01 (General tolerances: ISO 2768-fH).*

A standard sensor head C01 has a titanium housing with a diameter of 4 ± 0.05 mm and 13 mm length, as shown in figure 5. Its weight is approximately 0.5 g.

Furthermore, the sensor heads can be delivered without protective housing (-NO). In this case, a 2.8 mm diameter glass sleeve can be used for mounting and its weight reduces down to approximately 0.2 g.

4. OPTICAL FIBER

The sensor head C01 is interfaced with the **PICO**SCALE controller via an optical fiber with an FC/APC connector (8° angled end face to minimize back-reflections). By default, the sensor heads are equipped with a 900 µm fiber, which is 1.5 m long.
Both the fiber length and the actual fiber type can be customized. We offer the following options for the fiber type:

-B: 3 mm stainless steel tubing. Vacuum option on request.

4.1 Stainless steel tubing for high vacuum

The protective fiber tubing from stainless steel requires special fixture to the sensor head. Thus, directly behind the sensor head the fiber is rigid and cannot be bent, cf. Figure 6.

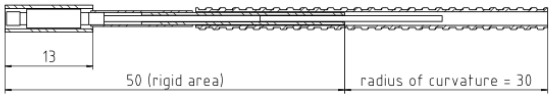


Figure 6. *Sensor head with stainless steel tubing (vacuum option). See text for details.*

5. ORDER CODE

The order code of the sensor heads is built as follows:

PS -SH -C01 ***-B -C -D -E -F -G***

The placeholders can be replaced by the respective option code. These codes are given in the table below. If you do not specify an option, the default value is used.

Category	Shortcut	Description
-B Vacuum/cryostat option	No entry/default	Operation in ambient conditions
	-HV	High vacuum compatibility; down to 10^{-6} mbar
	-UHV	Ultra-high vacuum compatibility; down to 10^{-11} mbar
	-CRYO	Cryostat compatibility. Please contact SmarAct.
-C Reference mirror position	No entry/default	Reference mirror on side surface of beam splitter; probe beam exits at front of sensor head
	-FR	Reference mirror on front surface of beam splitter; probe beam exits perpendicular
	-ER	External reference mirror; two probe beams exit sensor head for differential measurements
-D Beam splitter ratio	No entry/default	Beam splitter has 50% transmission
	-BSR80	Beam splitter guides 80% of light into probe beam
-E Fiber length	No entry/default	1.5 m fiber length
	-3.0	3.0 m fiber length. Other lengths on request.
-F Fiber type	No entry/default	900 µm jacket recommended minimal bending radius: 20 mm (ambient/HV); 30 mm (UHV/Cryo)
	-B	3 mm stainless steel tubing recommended minimal bending radius: 30 mm vacuum compatibility on request
-G Housing option	No entry/default	Titanium housing; weight 0.5 g
	-NO	No housing; glass sleeve only (diameter 2.8 mm); weight 0.2 g

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