

Closed-loop positioning of a sample with interferometric precision

INTRODUCTION

Accurate positioning of a sample is one of the core challenges in today's high-precision manufacturing and research. The standard approach is to control the position using a high precision positioning system with integrated position feedback. However, the sample can be mounted quite far away from the integrated sensor, so that possible drifts cannot be controlled with the desired accuracy.

The **PICOSCALE Interferometer** can be used to measure at (or at least very close to) the point of interest (POI). It uses an infrared laser beam which is reflected off a target surface to create an interference pattern. This pattern is evaluated and contains the information on the target's displacement. As the resolution and accuracy is typically far beyond that of linear encoders that use periodic patterns on glass scales, positioning of samples can be brought to a new level of precision.

INTERFEROMETRIC DISPLACEMENT SENSING

The **PICOSCALE Interferometer's** core components are the controller with a laser source and a sensor head, which is connected via an optical fiber. The sensor head contains a beam splitter as the central part of a Michelson interferometer, where the reference mirror can be directly coated to one of the beam splitters side surfaces. The measurement beam exits the sensor head and must be aligned to a target surface so that the reflected light enters the sensor head again. This way the reflected beam from both the reference and target mirror can interfere. The interference pattern is guided back into the controller and evaluated using high speed detection electronics and fast algorithms. As a result, a displacement signal with picometer resolution and an accuracy in the single digit nanometer regime is provided. (For details on the specifications please refer to the corresponding specification sheets of the controller and the sensor heads.)

The displacement signal is available for further processing in several ports:

- The displacement data or other derived data sources such as velocities, calculated angles or timing signals can be sent to a user PC for analysis or post-processing. A feedback-loop can be closed using software.
- Using the **PICOSCALE Breakout Box**, displacement data are available as quadrature signals

(AquadB) or can be received via a serial data interface. The feedback loop can be closed on a hardware level.

- Using the SmarAct SI interface, the position data can be directly sent to SmarAct's modular control system **MCS2**, which can use the data for direct and low latency feedback to control a SmarAct positioner.

In the following we will describe the last approach.

CLOSED-LOOP CONTROL USING PICOSCALE AND MCS2

To demonstrate the functionality, an exemplary setup has been realized. A schematic of the setup is shown in Figure 1 and a photograph is shown in Figure 2.

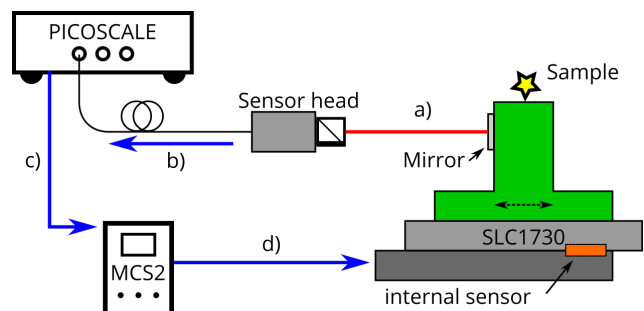


Figure 1. Schematic of a demonstration setup. See text for details.



Figure 2. Photograph of a demonstration setup. See text for details.

A **PICOSCALE** sensor head is aligned to track the displacement of a target mirror (a) which is glued to a

cantilever. The interferogram is guided to the PICO-SCALE controller via an optical fiber (b), where the displacement signal is calculated. This signal is directly sent to the MCS2 via the SmarAct SI interface (c). This way, very small latencies (below 100 μ s) are realized. The MCS2 uses these data as sensor input and closes the feedback loop while steering a SmarAct SLC1730 translation stage (d), which holds the cantilever structure.

DIFFERENTIAL MEASUREMENTS

Please note, that the mirror is only stable relative to the sensor head. Thermal drifts of the base plate or the mounting will cause the mirror to follow this drift. (On the other hand, this can also be desired in specific applications!)

Using an optically differential setup, a target can be controlled relative to another point of interest and environmental disturbances are suppressed. An exemplary setup is shown in Figure 3. Please contact SmarAct for more information on differential measurements.

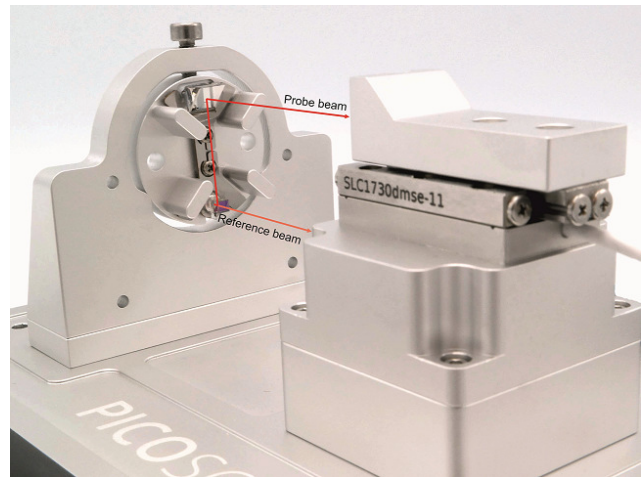


Figure 3. An exemplary setup with a differential measurement head. By closing the feedback loop, the differential distance of the mirror on the slide and the mirror on the post is kept constant. Highly accurate positioning is possible with these kind of setups!

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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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