Using the FPS3010 Optical Interferometer in Quality Control of a Nanopositioner

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Confidence is built on quality

Despite all efforts, in real-life production processes errors that lower product quality are still possible. Such errors generate additional costs and in the worst case customer confidence can be damaged. Optical sensing in quality control can help to reduce these risks to a minimum by achieving high quality standards. The FPS series of optical displacement measurement sensors with its broad range of optical collimators is ideally suited to detect and limit errors to a minimum in various applications.

For attocube, the precise determination of a positioner's repeatability is one important parameter for characterizing its performance during a standard quality check. This note describes the implementation of the FPS3010 interferometer sensor into a quality control setup to characterize the repeatability of a standard positioner.

The FPS3010 offers quick and highly precise relative measurements of targets at up to 1 m distance moving with 2 m/s maximum velocity. One major benefit of these robust sensors is their capability to measure also in extreme conditions, such as vacuum, cryogenic temperatures as well as in high magnetic fields. This is especially important here, as thermal drifts can be reduced by introducing the whole test setup into a vacuum chamber.

Fully automated testing

The positioning repeatability of an ECS3030 closed loop positioner controlled by an ECC100 closed loop controller was measured in ambient as well as in vacuum conditions. Only the measurements in a vacuum of 4×10^{-7} mbar are shown here.

The ECS3030 positioner features an internal optical encoder with a resolution of 1 nm. Together with the ECC100 controller, the setup is capable of positioning over 20 mm with a specified repeatability R of (better than) 50 nm.

To check the latter specification, the position of the motor was externally referenced by a FPS3010 interferometer arranged on the same breadboard as the motor. The sensor was mounted on a flange made from aluminium. To minimize the effect of thermal fluctuations, the measurements were performed in vacuum.

For the test, the motor was programmed to repeatedly approach random positions distributed along nearly the full travel range (some space was left free to the positive side of the travel range). After approaching one such position, the motor was moved away by 1 mm, then programmed to go back to the same position again. Using the FPS3010 as external reference, the difference in "real" position of these two successive approaches was measured. 1 s of waiting time before each measurement was introduced to keep errors to a minimum due to residual vibrations.

Encouraging Measurement Results

The result of the test shows a homogeneous distribution of the difference in position over the full travel range (see Fig. 1). A slight increase towards both ends of the travel range can be seen from the graph.

The histogram of the data is plotted in Figure 2. The deviation σ can be calculated to 13.2 nm RMS. The slight asymmetry and the displacement of the center by $\triangle \approx 9$ nm arises from the fact that the intermediate displacement was always performed towards positive side, hence the shift is only measured for approaches
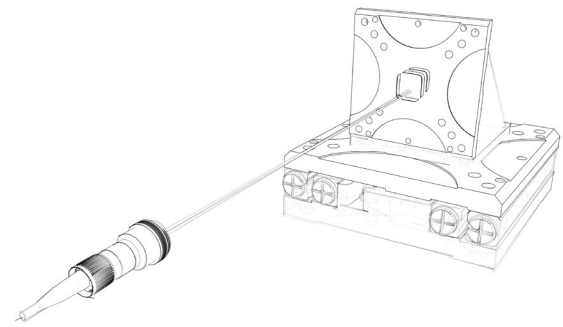

Figure 1: *Sketch of the setup. The sensor head of the interferometer is used to externally reference an ECS3030 positioner in a repeatability measurement setup.*

from the positive direction. From this data, one can see that the repeatability criterion of $R < 50$ nm is well accomplished.

Conclusion

We implemented an FPS3010 to automatically characterize the repeatability of an ECS3030 as a part of our quality control process. The simple and robust alignment of the sensor allows for direct integration in production as well as for high throughput in quality control.

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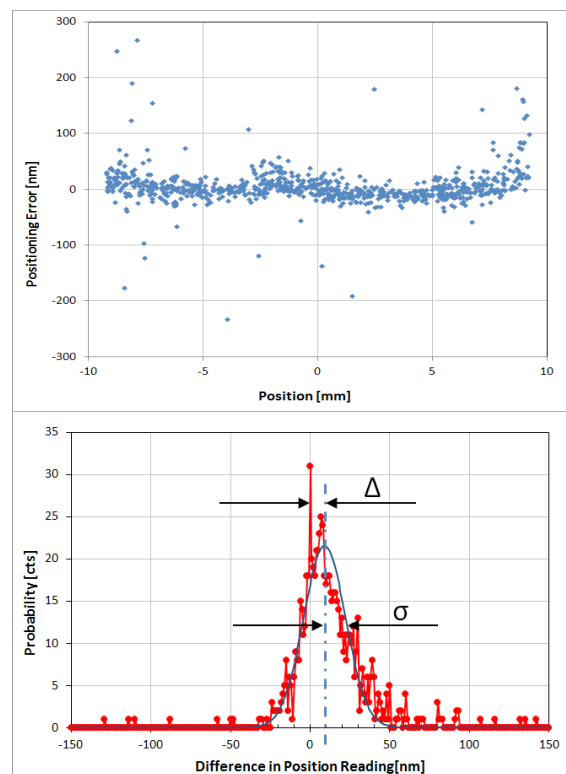
Figure 2: *Top: Difference in position measurement along the axis of an ECS3030 positioner. Each dot represents the position difference of two successive approaches towards the same position, measured using an external FPS3010 interferometer.*

Bottom: Histogram of the data. The standard deviation σ is evaluated numerically to 13 nm.

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