## Unconventional, lateral measurements with laser focus sensors for nanopositioning stages

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**Abstract**

Highly accurate nanopositioning stages are an important component in the production of modern nanotechnological devices. The measurement and calibration of nanopositioning stages using unidimensional or bidimensional artifacts is possible with various instruments. Traditionally, optical microscopes and linear encoders represent a common choice for that [1 - 5]. In this work, Laser Focus Sensors (LFS) that are originally intended to detect the vertical distance from the sensor to an object are used for characterization of lateral stage movements using suitable artefacts. The LFS sends a circular laser spot and detects the changing of vertical positioning, which is connected to the change of the reflected spot shape [6]. By use of a quadrant detector [6], the LFS can provide a nanometer resolution in vertical measurements [7]. However, it is possible to obtain an intensity signal of the returned spot and refer it to lateral movement, for example by detecting different reflexive materials on a cross grid made of glass substrate and attached chromium lines. In this work, the lateral distances between structures of such a cross grid with 40 µm pitch are measured with an LFS, where the motion of the cross grid is performed by a planar nanometer positioning system. This positioning machine, see figure 1, consists of planar direct drives which move a platform in six degrees of freedom within a range of ⌀ 200 mm, and is referenced by differential laser interferometers. The load of the platform is supported by planar aerostatic bearings and additional lifting modules are used to realize stable vertical movements within a range of 25 mm. For this combination of the LFS and the 6DOF positioning stage, a 4 nm standard deviation of cross grid center positions distance is achieved over a range of 4 mm for X and Y directions in short term. In long term, less than 20 nm standard deviation, figure 2, was determined, with the room in standard ambient conditions and no further corrections. Simultaneously, height measurements are still possible, even though the different reflection properties of the cross grid may reduce the precision. Based on these achievements, the use of an LFS to measure lateral distances is considered as a suitable alternative for optical microscopes and linear encoders in the characterization of nanopositioning stages.

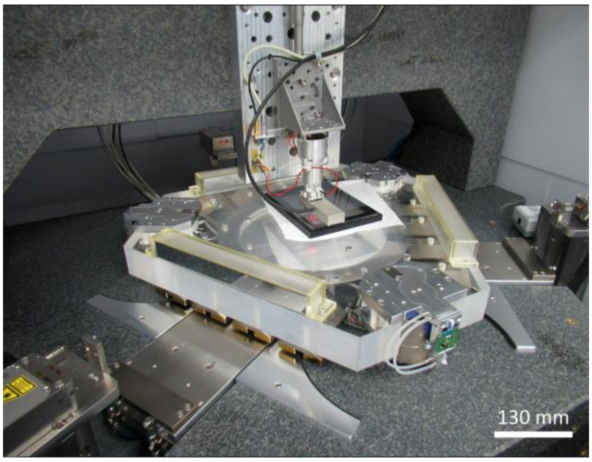


Figure 1 – Setup of nanopositioning system used with the LFS.

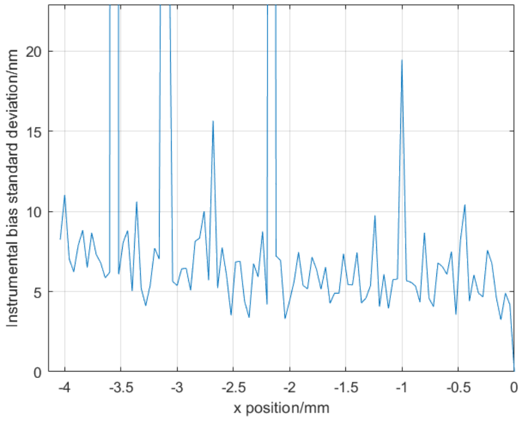


Fig. 2 – Standard deviation for long-term experiments – the outliers were not used in the analysis.

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