Distortion characterization of a metrological UV- microscope for uni- and bidirectional measurements

J. Krüger, H. Xu, W. Häßler-Grohne, R. Köning, B. Bodermann
Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany
jan.krueger@ptb.de

Abstract

At PTB, a one-dimensional high precision length comparator, the Nanometercomparator (NMK), is employed to perform optical calibrations of line scales, photomasks and encoders. Until now, calibrations have been limited to unidirectional measurements with an optical imaging system optimized for this purpose. Measurement uncertainties down to the nanometer regime are achieved [1]. However, the calibrations capabilities of the NMK shall be expanded to bidirectional measurements, i.e. measurements of distances between two opposing edges such as line width or diameter measurements. Thus, the vision system has been recently replaced with a new UV-microscope better adapted for this purpose.

The reflective microscope is equipped with two objectives, both providing a magnification of 200x while the numerical apertures are 0.55 and 0.9, respectively. The illumination light at the operation wavelength of 365 nm is provided by an UV- LED and is guided by a multimode fibre into the setup.

Reliable optical bidirectional measurements always require rigorous simulations for the detection of the edge position in the actual measurements [2]. Thus, the microscope is characterized carefully to determine all parameters, which are needed to perform such simulations of the microscope imaging.

In this contribution, we elaborate on the distortion effects of the microscope. The employed camera chip has 1392 x 1040 pixels with an effective size of 23.8 nm. A two- dimensional grating of dots is used for the distortion investigations. The grating period of 1 µm in both directions has been calibrated with an accuracy of 20 picometer by diffractometry.

At first, several images are taken at different positions on the grating. The dot locations are determined with a correlation of the image and the ideal dot positions. These locations are influenced by the distortion of the microscope's imaging and local disturbances of the dot positions due to unavoidable manufacturing errors. An averaging of the determined dot locations across all images reduces the influence of local disturbances. A Zernike polynomial fit is applied to determine an expression for the microscope distortion. A residual dot location error of below 5 nm remains (see fig. 1). We show first investigations in applications of distortion correction on measurement of circular structures.

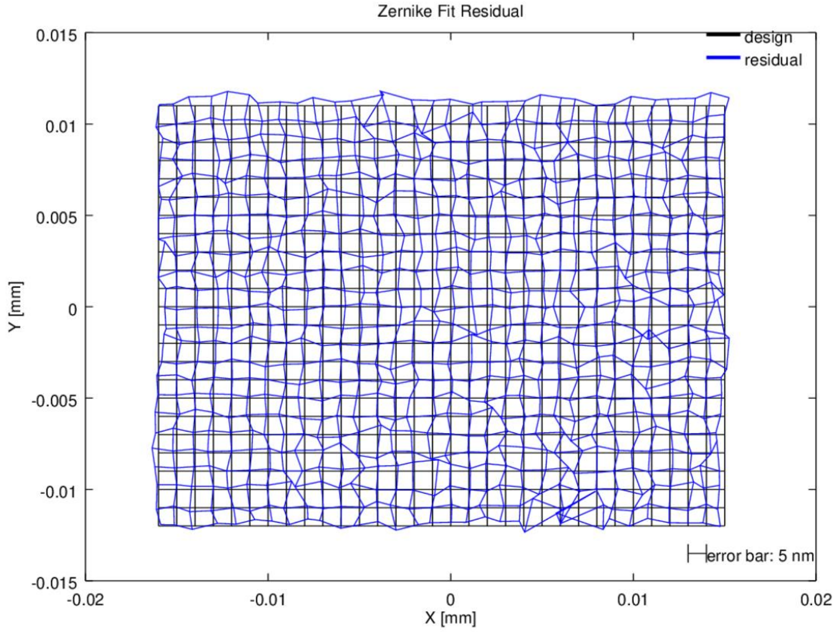

Figure 1: Residual dot location error of the grating after the Zernike polynomial fit

References

[1] H. Bosse, G. Wilkening, Meas. Sci. Technol. **16**, 2155 (2005)

[2] B. Bodermann, R. Köning, et al., Fringe 2013 (Springer-Verlag, Berlin Heidelberg, 2014)