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Development of manufacturing processes for coordinate-based 3D μ-standarts

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An important contribution to the success of micro- and nanotechnologies was and is the possibility of being able to visualize and measure objects on this scale. The calibration of 3D-microscopes today requires not only the calibration of the side and height scales, but also the calibration of the flatness error of coordinate planes as well as the shear of coordinate axes. To meet these requirements, suitable standards and reference metrology are needed. The standards currently available on the market for optical microscopes are for different individual calibration steps (lateral, height steps, shape standards).

The 3D-standarts combine the properties of the commercially available standards and are therefore universally applicable. The advantage of this 3D-standards is that the calibration factors for all three axes and even the coupling factors between them can be determined in one measuring and evaluation step. Otherwise, these factors must be determined separately, e.g., with step height and 1D-/2D-grid standards, which means a multiple of measurement and evaluation effort and thus costs.

With this alternative calibration approach, geometric misalignments can be determined using 3D-reference structures with known object coordinates. The approach is based on the principle of measurement marks, as used in close-range photogrammetry, where the actual size of an object can be calculated from the comparison of the object with the measurement mark. Since the 3D-coordinates of the marks on the reference structure are known, the calibration process involves a geometric transformation of the measured object coordinates of the marks to the known object coordinates of the marks according to the calibration model.

Currently used 3D-standarts are produced with FIB [1,2]. Each standard is therefore a cost-intensive custom-made product that also requires time-consuming calibration. Especially for larger structures for the calibration of optical 3D-microscopes, production using FIB is not feasible.

Therefore, wafer-based mask processes for the fabrication of 3D-standarts are to be developed so that many structures can be reproducibly fabricated and adapted to the respective device to be calibrated. The aim of the project is to provide both a validated, wafer-based manufacturing process for 3D-standarts in different sizes and a calibration strategy that ensures traceable reference measurement in verifiable accuracy levels.

First results were achieved by stepwise build-up of silicon oxide layers in combination with a dry etching process. In this way, two-level pyramid structures can be produced onto which the marker for calibration can be applied with the help of lift-off. These structures can be produced from a size range of 5μm edge length for use in the SEM, up to edge lengths of 225μm for optical 3D-microscopy.

However, the structures have a slope angle of about 80°, which works well for calibration of 3D-microscopes, but for SEM calibration the angle must be <70° to provide enough height information for height calibration. To lower the slope angle further, additional etching methods will be evaluated in the further course of the project.

1. M. Ritter et al: A landmark-based 3D calibration strategy for SPM. Meas. Sci. Technol. 18 (2007) pp. 404–414.
2. M. Hemmleb at al: Automated geometric SEM calibration, GIT Imaging & Microscopy 1/2015, pp. 42-44.

Category

Other

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