3D calibration for SEM and optical microscopy - First results with next generation 3D standards

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Marker based 3D standards, in the form of cascading step-slope pyramids, enable the calibration of all three scaling factors and all three coupling factors of measurement instruments using only a single sample and a single measurement [1]. They are suitable for automated calibration and therefore offer better convenience than conventional methods and are therefore increasingly applied [2]. With the introduction of a new scalable wafer-based manufacturing technology, the current application range for calibration of atomic force microscopy (AFM) and SEM can be expanded to optical 3D measurement instruments. First prototypes of these next generation 3D standards are applied for example calibrations of topographic 3D-SEM and confocal laser scanning microscopy (CLSM). The results show the easy and smooth application of the new standards as well as the high conformity of the calculated calibration parameter with conventional methods.

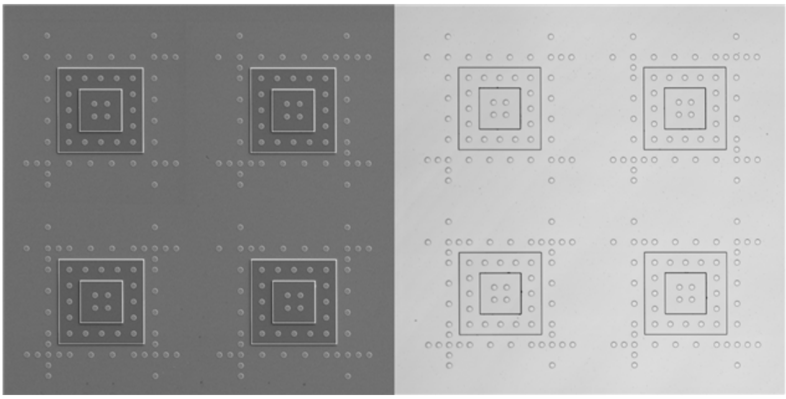
Currently used 3D standards are produced with FIB. Each standard is therefore a cost-intensive custom-made product that also requires time-consuming calibration. The maximum size of these standards is 80 µm with a marker diameter below 1 µm, which cannot be sufficiently resolved with optical 3D microscopes. Therefore, a wafer-based mask process for the fabrication of 3D standards was developed, allowing many structures to be fabricated reproducibly and the geometric dimensions to be adapted to the respective device to be calibrated. First results are prototypes with sizes of 400 µm and 1200 µm for use with optical microscopes, as well as standards with 80 µm size as replacement for AFM and SEM calibration [3]. Figure 1 (SEM and CLSM image with field of view about 400 µm) shows a first prototype, which was successfully used for the calibration of a CLSM (Olympus Lext OLS 4100). The calibration results were compared to the results from a conventional calibration which was carried out as a combination of a step height and a grid standard.

Compared to currently established traceability of FIB standards, which finally based on a reference measurement with a metrological large-range AFM (Met. LR-AFM), providing the required reference data for the wafer-based manufactured standards is easier and more efficient due to their better conformity. Therefore, a combination of traceable calibrated SEM and stylus profilometry was used for the measurement of the reference data [3].

For the coordinate measurement of the reference marks with subpixel methods, as well for the calibration parameter estimation with statistical methods, the dedicated software microCal was applied, which was already validated for this purpose [4].

The prototypes of the next level 3D standards can be used with the applied CLSM and the calibration software microCal without any problems and due to automatization very effective. All markers were measured with the required accuracy. In comparison with the more complex conventional CLSM calibration, the difference between lateral and height scale is below 4x10-4 and difference in lateral shearing is 1x10-4. In addition, a significant vertical shearing was determined, which is hardly possible to identify with conventional methods.
Ongoing work is on further accuracy aspects of the new calibration samples and the specification of the uncertainty budget for providing traceable reference data. Due to the promising results, it is planned to make the new generation of 3D calibration samples commercially available in the near future.

Graphic:



Keywords:

3d metrology standards calibration

Reference:

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