4-Quadrant-large-angles-BSE-Analysis: Problems and Approaches for quantitative 3D-Surface Reconstruction

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Using the signals of 4 backscattered electron detectors with different large detection angles in the scanning electron microscope (SEM), the 3D sample morphology of catalysts, fractured surfaces, and micro-devices can be analysed. The surface reconstruction is very fast since the surface morphology is calculated from the four simultaneously recorded backscattered electron images, e.g. using the software MEX 4.2 (Alicona Imaging GmbH). As reported previously [1-3], the relative heights and surface gradients are reconstructed very well (qualitative reconstruction). Unfortunately, the 4-Quadrant-large-angles-BSE-Analysis (4Q-analysis) has problems in determining heights of surface structures quantitatively. Therefore, a new fast exchangeable height calibration standard optimised for the 4Q-analysis has been developed and calibrated using an interferometer controlled large range scanning probe microscope (LRSPM) [4, 5]. Moreover, a fast analysing and data correction software package microCal/microTools (m_2c microscopy measurement & calibration GbR) has been developed that corrects the results of the 4Q-analysis by the calibration data obtained from the height standard [5].

In this paper we present results from the evaluation of the new equipment from which the next steps for the optimisation of the system can be derived. It is well know that the accuracy of the 4Q-analysis depends on many parameters of the detectors and SEM-settings, but it is necessary to specify their influence on the accuracy of the 4Q-analysis. As a well known test sample, we used the calibration standard itself which consists of 3 pyramids with 264 reference markers (nanomarker) with known x-, y-, z-coordinates. The software microCal measures and compares the coordinates of the nanomarker calculated from the 4Q-measurement with the reference values and determines scaling factors. The scaling factor in z-direction and its distribution over the sample are of particular interest in our case.

It was found that the scaling factors in x- and y-direction have a systematic deviation from 100% for all detector- and SEM-settings caused by an improper calibration of the SEM. This might be corrected easily.

The z-scaling factor is influenced by the detector- and SEM-settings in many different ways. A change of the SEM-magnification has a small influence only (**Fig. 1**), but even a small change of the scan rotation has a strong influence (**Fig. 2**). This effect is caused by errors of the surface reconstruction software MEX 4.2, probably due to a non consistent direction of the internal integration axis. Even tilting the sample and the change of the working distance changes the z-scaling factor. Using MEX 4.2 as 3D surface reconstruction software, a number of preconditions have to be considered. To avoid this, a new software development specialised on the 4Q-analysis is started, integrating well known computer vision methods and the physical background of the angular distribution of backscattered electrons. First results from this software will be presented at the conference.

Using the new 3D calibration standard, short time reproducibility of 4Q-analysis is quite good, but in the long term (>15 min), the z-scaling factor shows a strange variation

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without any clear tendency (**Figs. 3 and 4**). This effect is caused by the drift of the diodes' amplification , where each diode has an individual non-linear drift. More stable diodes, probably with a more efficient cooling, are required.

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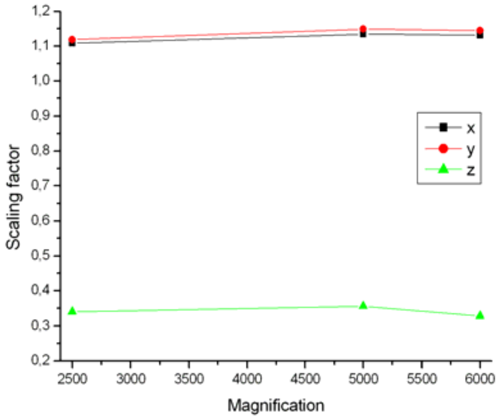

Figure 1. Scaling factors between measured and calculated dimensions to true values: the results of the 4Q-analysis is influenced by the magnification marginally

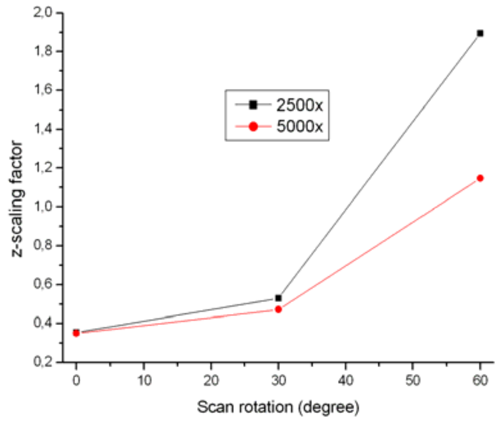

Figure 2. z-scaling factor of measured heights with respect to true heights: the results of the 4Q-analysis are strongly influenced by the scan rotation

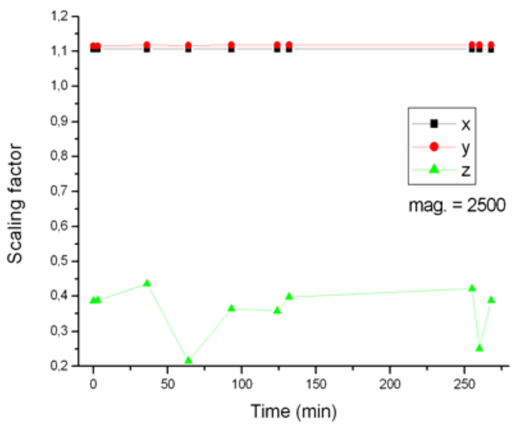

Figure 3. Scaling factors against time: the detector drift yields to unsystematic errors in height reconstruction with 4Q-analysis

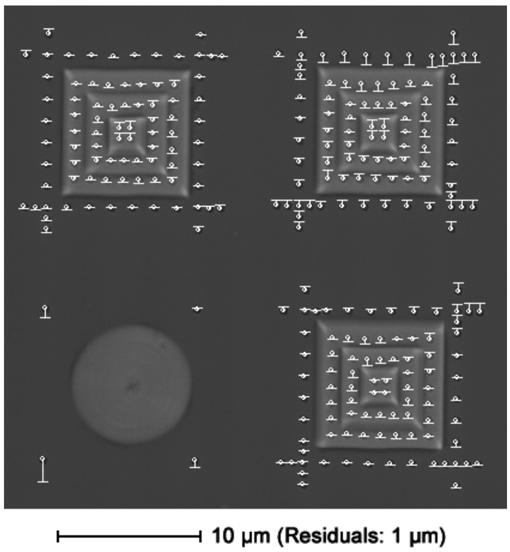

Figure 4. Scale corrected 3D surface data set of calibration standard: residuals of 4Q-analysis in z-direction

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