

## 3方向画像 (Auto Calibration) の評価

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### Introduction

The scanning electron microscope (SEM) is an excellent tool for the characterisation of surfaces. It offers the possibility to acquire images with a lateral resolution up to 1nm at a large depth-of-focus and with high contrast. The scanning process of a surface leads to a two-dimensional image of a three-dimensional surface. Nevertheless SEM images reveal also 3D information. In order to access this information conventional approaches analyze stereoscopic images. The major drawback of this approach is found in the sensibility to the accurate determination of the calibration data, namely the tilt angle. The user is faced with the difficult task to determine the accurate tilt angle, as most stages do not have a true angle resolution of 0.1 degree [1, 2]. In order to evaluate the accuracy of the system a known depth standard (Fig.1 - certified depth of 92µm) for tactile depth measurement devices was investigated.

### Comparison of StereoCreator and TriCreator Calculation

#### StereoCreator Calculation:

Two images are captured by eucentric tilting of the specimen. The software is automatically determining corresponding points in these two images. Together with the calibration parameters (working distance, pixel size and tilt angle) the topography of the surface can be reconstructed. This so called Digital Elevation Model (DEM) forms the basis for the various analysis operations. The minimum ratio of the height to the diagonal is 1:70.

#### TriCreator Calculation:

The TriCreator generates a 3D model from three different tilted SEM images. Due to the automatic determination of the accurate tilt angles an improved accuracy can be achieved.

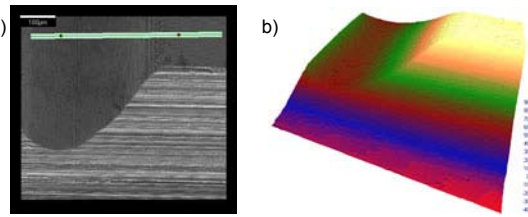


Fig. 1  
a) Secondary electron (SE) image of the depth standard with marked line for profile measurement  
b) calculated digital elevation model (DEM) - pseudo coloured

#### SE-Image Acquisition Parameters:

acceleration voltage: 20kV  
working distance: 4.9mm  
image resolution: 2048 x 1887  
pixel size: 0.3125µm  
eucentric tilting

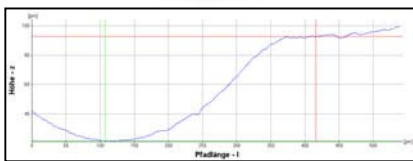
#### Optimal Tilt Angle Calculator

Depending on the length, the height and the image resolution the software calculates the ideal tilt angles. For our example tilt angles between 10 and 17 degrees have been calculated.

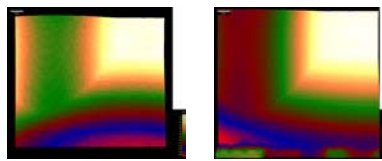
2方向

3方向

#### StereoCreator Calculation

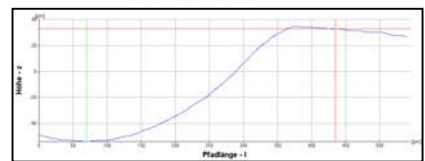


tilt angles 0 +5 degrees  
profile measurement 72µm

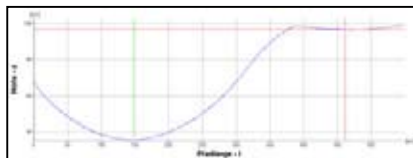


pseudo coloured depth image with the color bar

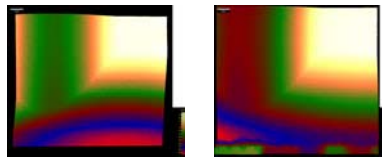
#### TriCreator Calculation



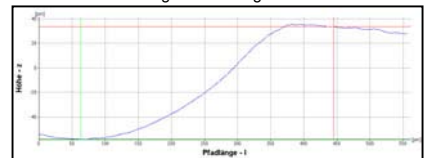
tilt angles -10 0 +5 degrees  
profile measurement 87µm  
no automatically determined tilt angles  
calculated with tilt angles from stage



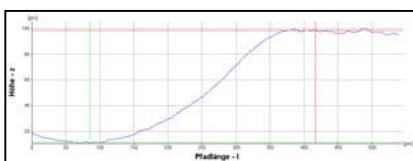
tilt angles -10 +20 degrees  
profile measurement 62µm



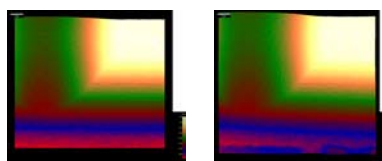
pseudo coloured depth image with the color bar



tilt angles -10 0 +5 degrees  
profile measurement 94µm  
automatically determined tilt angles -9.5 0 +4.5  
calculated with wrong working distance (WD=10mm)



tilt angles -10 +5 degrees  
profile measurement 86µm



pseudo coloured depth image with the color bar




tilt angles -10 0 +5 degrees  
automatically determined tilt angles -9.5 0 +4.5  
profile measurement 93µm

Best

### Conclusions

It could be shown that the use of the TriCreator calculation gives better results than the StereoCreator approach. Working distance (WD) has no significant influence on the accuracy of the calculation, except WD is too small at lower magnifications. The difference to the true height is caused by the inexact tilt angles. The TriCreator method automatically determines the true tilt angle up to 0.05 degrees accuracy based on image processing algorithms. Out of the optimized range of tilt angles suggested by the software it is better to go to smaller than to higher tilt angles, provided that there is a large height change in relation to the image diagonal. Further investigations will cover the evaluation of the TriCreator approach on e.g. roughness measurements.

#### Instrumentation

FEI Nanolab Nova 200  
Software Mex 4.1 by 

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#### Literature

- [1] St. Scherer, "3D Surface Analysis in Scanning Electron Microscopy", G.I.T. Imaging & Microscopy 3/2002, p. 45-46
- [2] E. Materna-Morris, N. Lakota and T. Merkel, U. Mücke and St. Scherer, "Methodenvergleich zur quantitativen Fraktographie", p. 1
- [3] A. Piffer and St. Scherer, "The SEM as a Profil Measurement Device", G.I.T. Imaging & Microscopy 2/2003, p. 18

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