A robust 3D scanning technique for SEM

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Abstract

This work proposes and demonstrates a robust SEM technique that uses the same photogrammetric algorithm as light-bases instruments, but covers the micron range that is beyond the limit of optical 3D scanners. **The aim is to provide a technique for automated data acquisition and reconstruction.**

Method

The new approach avoids limitations from SE-specific edge and charging artefacts, as well as restrictions in stage positioning at large angles or short working distances. Sample is mounted on a nanotip, tilted, rotated and imaged

1. Acquisition geometry is determined by point matching in BSE or EBAC images
2. Fine points/mesh are extracted/calculated from the raw EBAC images
3. Texture is extracted from BSE signal

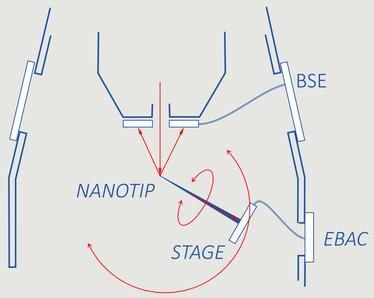

Figure 1: diagram of proposed set-up illustrating use of BackScattered Electron (BSE) and Electron Beam Absorbed Current (EBAC) signals.

Experimental

Test object is uncoated Portland cement powder, as it contains µm-range particles and it is prone to charging. Nanotip was placed in the centre of the stage, tilted at 60°, rotated 360° and imaged with 1,024x1,024 pixels at every 15°. The upgraded DSM982 was operated at 20kV accelerating voltage and 20 mm working distance, and the standard 30 µm aperture.

Scan data

EBAC and BSE images were recorded simultaneously for point cloud and texture extraction, respectively. SE images were dominated by strong charging of the uncoated particles – limited charging was still present in the EBAC images.

- EBAC images are better for 3D reconstruction, as they contain more details with no shadows and no signal outside the sample.
- BSE images are better for texture, as they have good compositional (atomic number) contrast

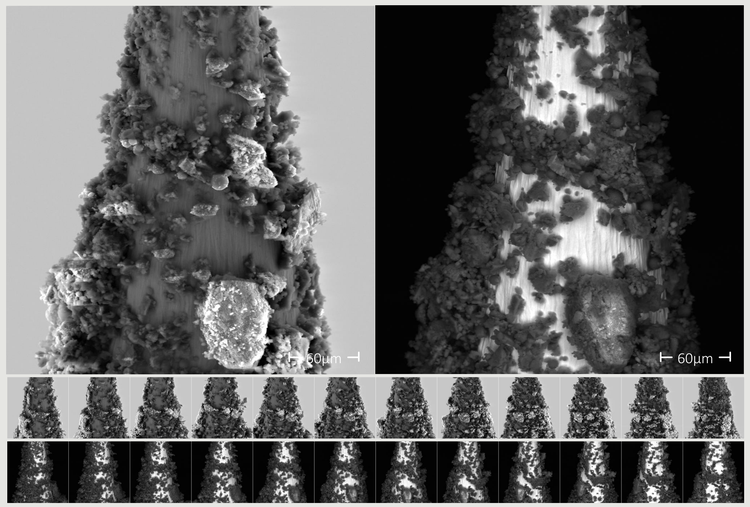

Figure 2: typical EBAC (top left) and BSE images (top right) input images recorded during the 3D scan, and 0° to 180° rotation series (bottom)

3D reconstruction

Automatic 3D reconstruction was done with Agisoft PhotoScan software, where the only manual inputs were pixel size and focal distance. Standard workflow included

1. Determination of positions and distortions from EBAC or BSE images
2. Fine point cloud extraction from EBAC images
3. Calculation of wire frame from EBAC point cloud
4. Extraction of texture from BSE images

3D model

Automatic processing was able to reconstruct a very dense point cloud, with a very good match to the original BSE and EBAC images.

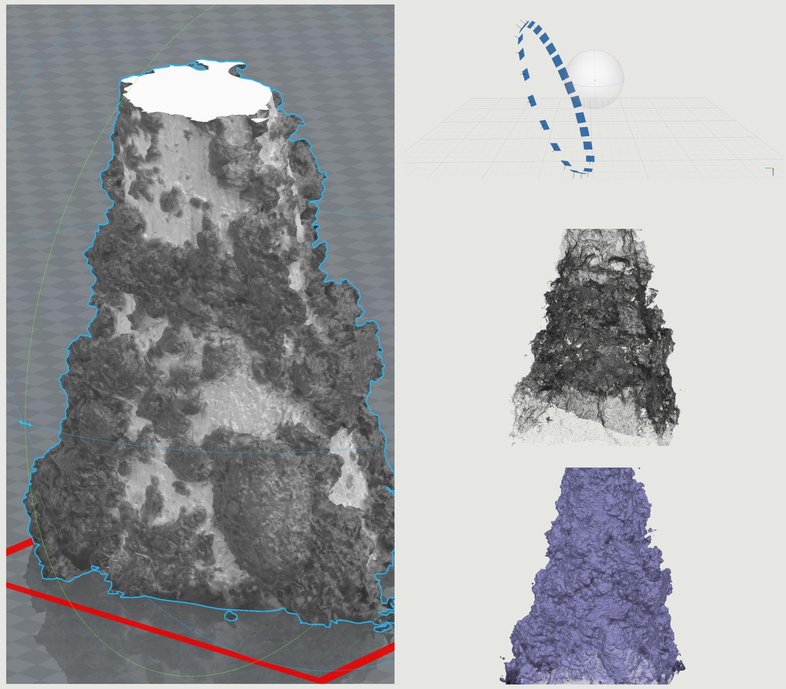

Figure 3: textured 3D model with atomic number contrast (left), alignment (top right), dense point cloud (middle right) and wire frame (bottom right)

Conclusion

This work lays out the simplest and most robust approach to 3D scanning in SEM to date.

References

- A Boyde and H F Ross, The Photogrammetric Record 8 (1975), p. 408
- L C Gontard et al., Ultramicroscopy 169 (2016), p. 80
- A Boyde, Journal of Microscopy 98 (1973), p. 452
- M Hemmleb et al., European Microscopy Congress (2016), p. 489

All data is recorded with BSE and EBAC acquisition add-ons installed on a Zeiss DSM982 FEG-SEM upgraded by point electronic GmbH, including DISS5 scan control and image acquisition, automated stage control, automated focus & stigmatism. Data is available upon request from the authors. Detailed technical specifications can be found at www.pointelectronic.de