Live quantitative BSE acquisition with standard-less calibration

Hemmleb, M.[1], Schmid, M.[2], Grauel, U.[1], Joachimi, W.[1] and Moldovan, G.[3]

[1] point electronic GmbH, Germany, [2] PNDetector GmbH, Germany

Conventional SEM is based purely on contrast imaging, as required for measurements of distances or angles, however knowledge of absolute intensity provides a deeper level of analysis that includes measurements of concentration or gradients. However, Backscattered Electron (BSE) imaging is rarely quantitative (qBSE) because it still requires calibration samples [1]. This work formulates an automated calibration method for standard-less BSE quantification.

There are five overall aspects of signal acquisition that need to be considered for calibration: signal digitization, signal amplification, detector response, geometrical alignment and sample topography.

Calibration of digitization describes relationship between analogue-to-digital units and input voltage, which is obtained by applying a range of voltages at the input of the imaging system. Calibration of amplification is similarly obtained by applying known voltages and recording the resulting gains. Calibration of detector response describes amplification vs. acceleration voltage, and requires a detector model with parameters measured experimentally. Required constants are energy loss without induced signal and leakage current. Geometrical alignment calibration requires knowledge of the SEM, including angles and positions of sample, electron beam, and detector in relation to the pole piece, as well as positions and shapes of sensitive areas within the detector. Sample and electron beam geometry is readily obtained from the SEM and rely on the standard calibration for magnification, scan rotation and working distance. Detector coordinates are calibrated through alignment with known samples, e.g. flat and horizontal sample surface, by means of equalising simultaneous BSE signals from segmented detector. Spherical aberration determined again by calibration with known sample and segmented BSE imaging.

These calibration steps are already sufficient for polished samples. For samples that present topography, the established live shape-from-shadow algorithm already uses the annular dependency of backscattered electrons to calculate sample surface orientation at each scan point, and thus again relies on simultaneous acquisition from segmented detectors [2]. This algorithm is now extended to calculate an integrated BSE signal in addition to surface orientation, as illustrated in Figure 1.

It will be shown that whilst the quantitative model required for calibration must include many parameters, each of these parameters is relatively simple and thus can be measured and applied during the acquisition to provide live quantitative analysis. Application to a range of samples of varying densities will also be shown.

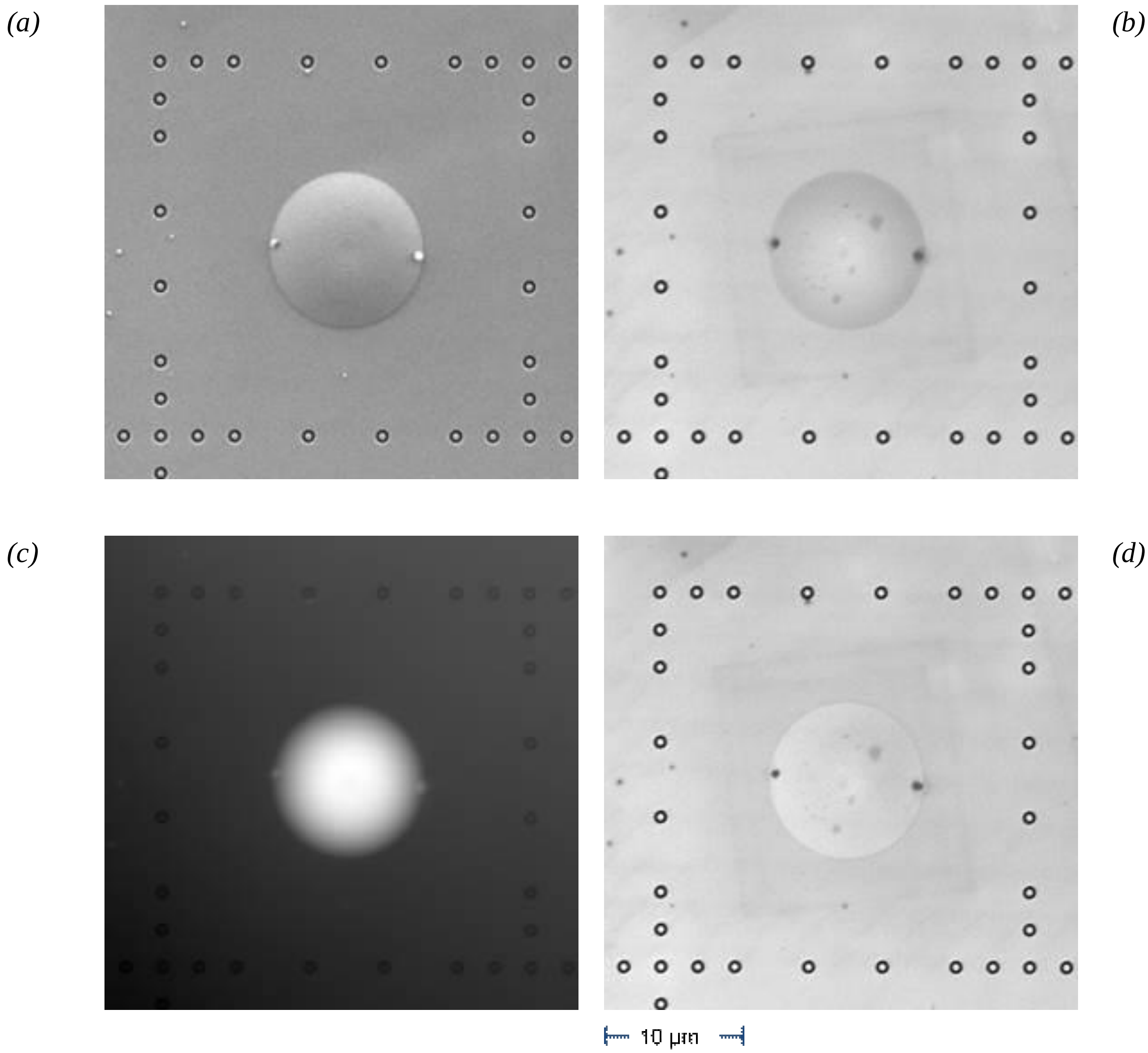

Figure 1. *Experimental (a-b) and calculated (c-d) images illustrating simultaneous extraction of topography and backscatter intensity for a test object of uniform composition. SE image (a) presents the dome-shaped structure surrounded by alignment marks. Conventional "compositional" sum of all BSE (b) shows radial intensity artefacts from centre to edges of the dome structure. The algorithm provides topographic (c) and backscatter intensity (d) images. Whilst artefacts remain at sharp interfaces in the calculated (d), e.g. dome edges and alignment marks, the calculated values are now free of radial intensity artefacts.*

[1] E. Sánchez *et al.*, Microscopy and Microanalysis (2012), 1355-1261

[2] D. Berger, M. Hemmleb, MC2017 Proc. (2017), 468-469