Direct calibration of retractable annular BSE detector

Radim Skoupy and Vladislav Krzyzanek

The Czech Academy of Sciences, Institute of Scientific Instruments, Brno, Czech Republic

The idea of surface coating layer thickness measurement using differentiation in back-scattered electron (BSE) signal intensity is facing a problem with normalisation of the captured signal accordingly to the actual detector settings and the electron probe current. In the papers dealing with quantitative imaging using BSE it is solved by comparison of the investigated sample signal with signal of sample with known composition and thickness. This approach may be called calibration using standards. The accuracy of such type of measurement is limited. The error of the measurement can reach up to 20 % at Pt layer with thickness of 25 nm [1].

We present a standard-less approach how to calibrate the annular BSE detector in imaging position (i.e., active area facing down towards the sample) for variation in beam current and local sensitivity of the BSE sensor. The method can be used also for other types of direct electron detectors which have, thanks to their location in the microscope chamber, the problem with direct illumination by primary electron beam as used in quantitative STEM [2].

Our solution is in deflection of primary electrons on an electron mirror and its impact on the BSE detector from its sensitive side. The reversion of electron trajectories is done at very smooth conducting layer of metal and application of negative sample bias at appropriate voltage as shown in the diagram (Fig. 1). We used 40 nm layer of sputter coated gold on a silicon substrate. By application of above mentioned calibration method we achieved an improvement of the accuracy of surface layer thickness estimation to error around 10 % on gold and molybdenum sample even with a thickness in nm range [3].

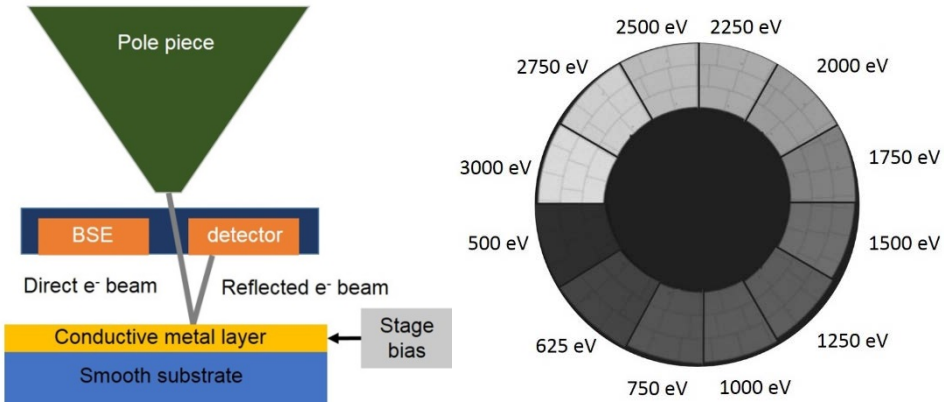

Figure 1: Principle of BSE detector calibration using a electron mirror (left) and selected annular segments of captured contrast dependency on various beam energies (right).

[1] M. Dapor et al, Backscattered electrons from surface films deposited on bulk targets: A comparison between computational and experimental results, Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms. 269 (2011) 1672–1674.

[2] R. Skoupy et al, Quantitative STEM imaging of electron beam induced mass loss of epoxy resin sections, Ultramicroscopy. 202 (2019) 44–50.

[3] R. Skoupy, T. Fort, V. Krzyzanek, Nanoscale Estimation of Coating Thickness on Substrates via Standardless BSE Detector Calibration, Nanomaterials. 10 (2020) 332.

[4] The authors acknowledge projects TN01000008 (Technology Agency of the Czech Republic) and TRIO FV30271 (Ministry of Industry and Trade of the Czech Republic).