Matching Low Voltage Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy of Positively Biased Samples

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The Agilent 8500 field emission scanning electron microscope (FESEM) operates at 0.5 – 2 keV providing high surface sensitivity not achievable in regular regimes of SEM at 15 – 30 keV. However the 8500 cannot be used for elemental analysis with energy dispersive x-ray spectroscopy (EDS) that requires ionization of inner shell electrons with higher than 2 kV ionization potentials. To combine imaging and EDS in the 8500, we perform imaging on grounded samples and EDS on samples biased to high positive potentials. However, positive biasing hampers collection of backscattered electrons and leads to the reduction of the field of view (FOV) and image shift. A proprietary calibration procedure compensates for these distortions and allows precise overlay of elemental maps with SEM images.

As shown in Figure 1 the center of the sample holder does not shift in the image upon biasing when it is located on the optical axis of the column but the FOV reduces due to the positive bias at the sample. If the stage is moved away from optical axis the FOV shifts in the direction of the stage move.

The electric field between the sample holder and the bottom of the column is nearly homogeneous, by design. In this case, the FOV ratio of the biased and grounded sample is a constant value depending only on the ratio of electron energies in the column and at the sample surface. For small displacements of the sample holder from the column axis, the image shift is proportional to the sample holder displacement. Therefore, calibration requires three parameters: optical axis coordinates, image displacement per stage shift and the FOV ratio.

Calibration is performed employing several patterned grids placed on the sample holder. The ratio of FOVs for the grounded and biased sample holder is calculated using Hough transform. The scaling factor is then applied to the images of biased samples and the shift between the images is calculated from normalized cross-correlation between them. The data from several calibration samples is fitted with a model assuming that the shift of the image is a linear function of the sample holder displacement with respect to the column axis. Employing the calibration, a feature identified in the image of a grounded sample can be blindly located in the biased sample with less than 20 um error. Further error reduction is possible using pattern matching in real-time x-ray maps and SEM images.

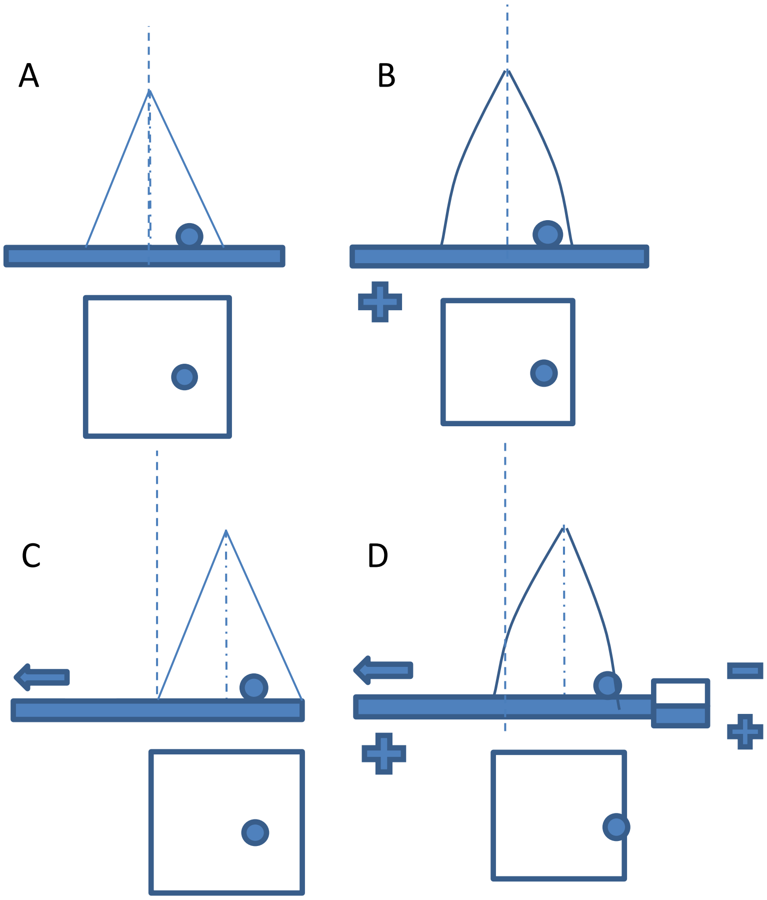

Figure 1. A sample with a round feature imaged in SEM. Thin lines show the trajectory of electrons at their extreme deviation from the column axis. The lower part of each figure shows the 2D image of the surface. A –The holder is grounded. B – The holder is biased. Because of symmetry the electron trajectories are symmetric with respect to the column axis. C – Same as A with sample holder grounded and stage moved. The trajectories of electrons are the same as in A. D – Same as B with sample stage moved. The trajectories of electrons are not symmetrical with respect to the beam axis. Virtual piece of sample holder symmetrizing the picture is added. If it was charged positively the trajectory of electrons would be exactly the same as in B. The compensating negative charge moves the scan area in the direction of the stage move.