Measurement error in metal nanostructures on insulating substrates induced by electron beam irradiation

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Scanning electron microscopy (SEM) is an important method for investigating and characterizing nanostructures. A well-known challenge in SEM is the investigation of insulating samples. As insulating materials do not provide a path to the ground they accumulate charge, evident as image drift and image distortions [1,2].

In this work we have fabricated metal nanostructures on insulating borosilicate glass using electron beam lithography to study the charging effect in the SEM. The measurements are carried out using two commonly available secondary electron-detectors in SEMs, namely an InLens- and an Everhart-Thornley (ET) detector. We experimentally quantify a measurement error, specifically a shrinking effect, induced by negative charging of the sample. We identify and discriminate several contributions to the shrinkage effect by varying microscope settings, including the probe current, the working distance and the acceleration voltage. We image metal nanostructures of various sizes and geometries, investigating the influence of metal coverage, scan-direction of the electron beam and secondary electron-detector used for imaging. The relative measurement error, which we measure as high as 35 % for some settings is found to depend on the acceleration voltage, the metal coverage and the type of SE detector used for imaging. In particular, it is found that the detection of SE_3 by the ET detector decrease the signal-to-noise ratio, which increases the magnitude of the shrinkage of up to 15 %. Finally, we present a method for estimating the second cross-over for charge balance in insulating samples that can be used to estimate the measurement error.

References:

[1] Goldstein J et al, *Scanning electron Microscopy and X-ray microanalysis* Third Edition, Springer, 2007

[2] Okai N, Yano T and Sohda Y, *Charge Modeling for Metal Layer on Insulating Substrate*, Japanese Journal of Applied Physics, 50: 06GC01, 2011