Improvement of accuracy of SEM based dimensional metrology

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Critical dimension metrology is the most crucial feedback in nanofabrication. SEM based methods are most commonly used because images of features are readily available. Analytical SEMs are not optimized for the task of quantitative metrology;[1] nevertheless, this is the only tool available to most companies at the R&D stage. SEM metrology involves uncertainty of the measurement in the image processing step. This is because SEM signal formation is an extremely complex process depending on the pattern geometry, materials, detector setup, and beam voltage. Thus, the image brightness profile has a complex relationship to the feature shape.

In this work, we used an analytical SEM for CD metrology applications on a quartz nanoimprint template. The SEM was tuned first to find the best reasonable condition for consistent manual operation. Beam characterization was done using the BEAMETR beam measurement technique. SEM images were taken at optimum conditions. The measurements were done using a) regular imaging processing software and b) physical model based processing tool, myCD. The quartz template was then measured using TEM crossections at selected sites to reveal profile information as a metrology comparison reference. Through this exercise, the metrology capability and fundamental limitation of analytical SEM operation with regular imaging processing was identified.

A considerable improvement was found with physics based imaging processing that involves SEM setup along with material information. The model based software was used to automatically extract critical dimensions and wall angles out of the SEM images. We concluded that physics based image analysis resulted in data almost identical to the TEM references.

1. D. C. Joy, “Some Issues in SEM-Based Metrology”, Proc. SPIE 3332, 102 (1998)

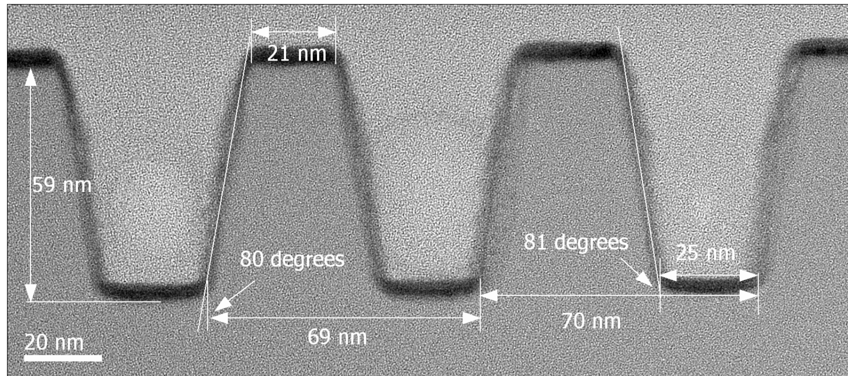

Figure 1. TEM images of disk templates were used to verify the accuracy of model based dimensional measurements

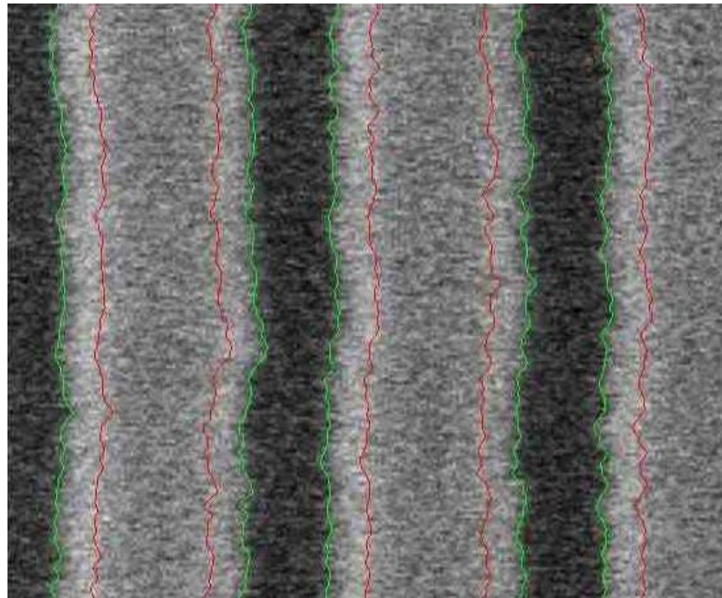

Figure 2. SEM image of a template with automatically extracted contours at the top and the bottom of lines. Model based extraction of contours shows considerable improvement in accuracy compared to regular image analysis software.