Interactions of Higher Order Tip Effects in CD-AFM Linewidth Metrology

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Critical dimension atomic force microscopy (CD-AFM) is a powerful tool for dimensional metrology at the nanometer scale, and linewidth metrology is one of the most important applications. One of the main challenges in CD-AFM width metrology is accounting for the effects of the tip on the apparent features in an image. The overall effect of the tip is to broaden the apparent width of lines (and narrow the apparent width of trenches) due to the geometrical interaction of the tip with the surface. To a first approximation, this effect can be well-modeled as a constant bias in width measurements, independent of the specific feature characteristics, by the width of the tip.[1]

Beyond this approximation there are a number of smaller tip effects related to the measurement details. Some of these result from the details and interactions of the tip shape and feature shape, resulting in small variations of the tip bias from feature to feature and measurement to measurement. These effects are sometimes called shape effects, secondary effects, or higher order tip effects.[2]

One source of higher order effects is due to the lateral dithering of the tip, which increases the effective tip width. However, in addition to this known effect, the tip dither may also affect the apparent edge heights of the tip flare, as shown in Fig. 1. The plot shows that the apparent edge height of a CD tip (CRD300 in this case) may have some dependence upon the lateral tip dither. Although the apparent tip width is expected to depend on lateral dither, the apparent edge height, at least in principle, would not be expected to depend on lateral dither.

Our analysis suggest that this apparent dependence results from the interaction of the fine details of the tip flare shape and the dither envelope with the specific algorithm used to estimate the edge height. Consequently, both the sign and the magnitude of the dependence are specific to every tip. This is one example of the inter-dependencies that can be present when evaluating higher-order tip effects. Although these are usually small, accurate metrology may require consideration of possible interactions between such smaller, secondary tip effects.

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[1] R. Dixson, et al., *J. Micro/Nanolith. MEMS MOEMS* **11** (1), 011006, (2012).
[2] N. G. Orji and R. Dixson, *Meas. Sci. Technol*. **18**, 448-455 (2007).

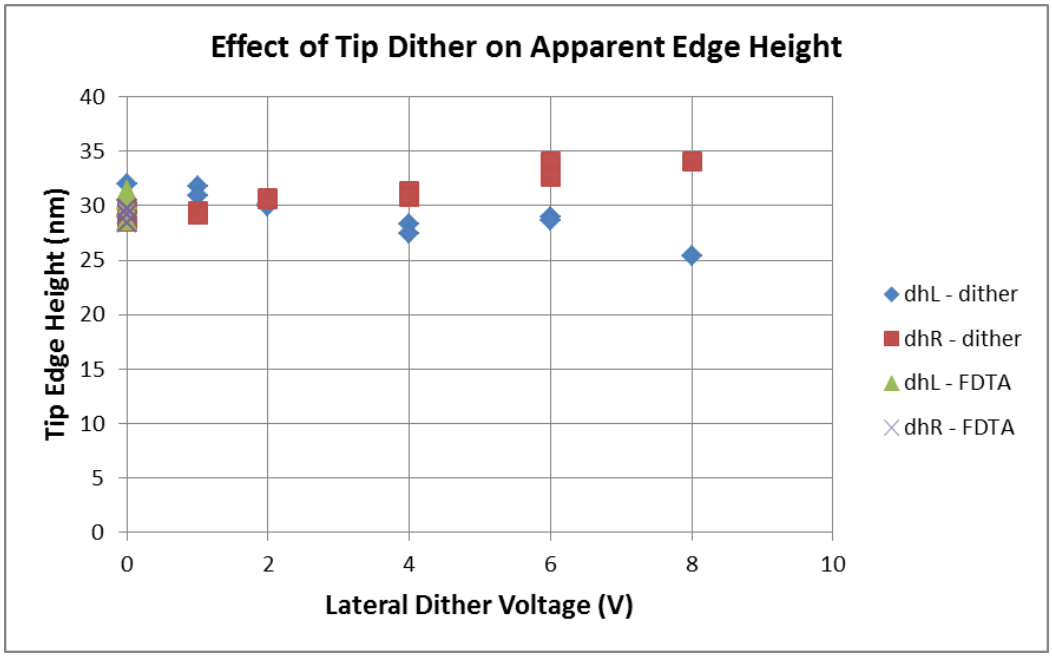

Figure 1: Apparent Tip Flare Variation: The plot shows that the apparent edge height of a CD tip (CRD300 in this case) may have some dependence upon the lateral tip dither. Although the apparent tip width is expected to depend on lateral dither, the apparent edge height is not.