Line Edge Roughness Contribution from Mask to Wafer

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As the technology node keeps shrinking, the k1 factor, a measure of lithography ease, has been decreasing through the years, and approaches 0.25 which is the resolution limit. At low k1 imaging, the effects of mask CD error are exaggerated[1-2]. As we know, without any other sources of variations, line edge roughness (LER) can cause CD variation[3]. In this paper, we will present our study of LER transfer from mask to wafer by understanding the LER transfer function as a function of spatial frequency.

In order to study the LER printability and determine the LER transfer function, a reticle with artificial programmed LER is used, where line edges on the mask are coded with periodic rectangle structures with different amplitudes and periods. The amplitude ranges from 80 nm to 200 nm with the step of 20nm on the mask, and the period changes from 80 nm to 2000 nm. The wafer exposure and processing experiments were executed on ASML scanners with two different cutoff frequencies: one is a 0.85NA ASML TWINSCAN XT:1250, and the other is a 1.35NA ASML TWINSCAN immersion 1900i. The "pupil blur" effect is expected to be captured by studying the image log slope degradation from sub-resolution blurring of line edges on the mask as the roughness periods get too small to pass through the lens. Figure 1 (a) shows the reticle image with programmed LER with amplitude of 80 nm and period of 80 nm, and Figure 1 (b) the corresponding image on the wafer from ASML 1250 exposure. According our initial analysis for 1250 exposed wafers, it indicates that 20 nm systematic mask LER will cause about 3.3 nm wafer LER; and 50 nm reticle LER will causes about 4.33 nm LER on wafer.

In the paper, the detailed experimental work and analysis for both ASML 1900i and 1250 exposures will be addressed, and the LER-induced mask error effect on CD variation across wafer will be investigated.

References:

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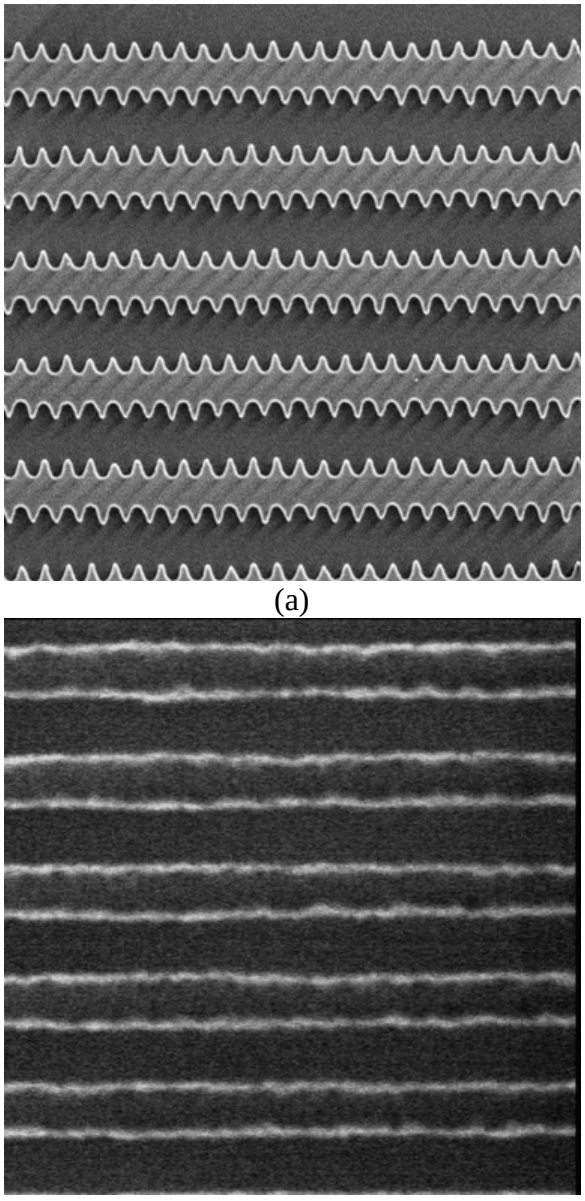

Figure 1. (a) Reticle image with programmed LER with period of 80 nm and amplitude of 80 nm; (b) the corresponding image on wafer with ASML 1250 exposure.