Investigating effects of aerial image averaging and pupil plane filtering on line edge roughness (LER)

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Line edge roughness (LER) is one of the most important challenges faced by current and future technology nodes. ITRS defined limits on LER are much less than what could be achieved for conventional state of the art imaging systems. There are many contributors to LER, which can be group under two main categories: resist/processing related factors and aerial image related factors (i.e. mask and source originated). In this paper, effect of aerial image averaging on LER power spectral density is explored for both IL and commercial type scanning systems. An approach is introduced to reduce LER through directional image plane averaging. The result is a frequency dependent averaging where low frequency roughness shows a unique response as compared to that at high frequencies. A three sigma value which is the most common parameter reported for LER would not be the ideal criterion whereas a power spectral density (PSD) is more appropriate. A significant amount of roughness reduction at low frequencies would be desired, even at the expense of roughness increase at high frequencies. This paper also explores a nontraditional approach for the reduction of mask induced roughness reduction where pupil plane phase manipulation is explored for various roughness frequencies. Pupil plane information can be controlled in either amplitude or phase. Both of these cases are shown to be useful in terms of mask induced roughness reduction.