CHE323/384 Chemical Processes for Micro- and Nanofabrication
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Homework #11

1. Consider a binary pattern of lines and spaces. Which diffraction orders pass through the lens under these circumstances:
   (a) λ = 248 nm, NA = 0.8, pitch = 300 nm, on-axis coherent illumination
   (b) Same as (a), but pitch = 400 nm
   (c) Same as (b), but illumination tilted by an angle $\sin\theta' = 0.5$

2. For a repeating line/space pattern and coherent illumination, derive expressions for the aerial image intensity at the center of the line and the center of the space as a function of the number of diffraction orders captured.

3. For λ = 248 nm, NA = 0.8, and pitch = 400 nm, below what value of σ is the image entirely made up of three-beam interference? At what σ value does one-beam imaging first appear?

4. Consider the case of dense equal lines and spaces (only the 0 and $\pm 1^{st}$ orders are used) imaged with coherent illumination. Show that the peak intensity of the image in the middle of the space falls off approximately quadratically with defocus for small amounts of defocus.

5. Compare the depth of focus predictions of the high-NA version of the Rayleigh DOF equation to the paraxial (low-NA) version by plotting predicted DOF versus pitch (use k_2 = 0.6, λ = 248 nm, pitch in the range from 250 to 500 nm, and assume imaging in air).

6. Consider the coherent image of a line/space pattern where only three orders are used to form the image:

$$I(x) = \left[\frac{1}{2} + \frac{2}{\pi}\cos(2\pi x/p)\right]^2$$

Calculate the image contrast, defined as

$$Image\ Contrast = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

For simplicity, assume the maximum intensity occurs in the middle of the space, and the minimum intensity occurs in the middle of the line (a common assumption).