EECS 243 – Advanced IC Processing and Layout

Fall 2000	**Office Hours**	**Prof. A. R. Neureuther,**
Tu, Th 3:30-5	**M, Tu,Th, (F) 11am**	**510 Cory Hall, 2-4590**
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Homework Assignment # 3, Due Th, Sept 21th, 00

Reading for Week#3: "The Lithography Process and Basis Simulation Models," Notes by AR Neureuther. Skip resist sections (5.3-5.5) till later. Correction on Problem 2.3 use $\Phi_P = (\lambda/4)(z/RU)\rho^2$. See Born and Wolf Section 9.1.3 in Chapter on Aberrations if you have questions about the integral. Use LAVA at **http://cuervo.eecs.berkeley.edu/Volcano/**

3.1 Pupil Energy Distribution and Image Quality.

Assume a wavelength of 248 nm and a NA of 0.5 and an illumination consisting of a single plane wave in the x=0 plane making an angle of 20^o to the normal when it strikes the wafer after passing through a clear field mask. An line equal space binary mask produces diffracted orders of amplitude ½, $1/\pi$, 0, $-1/(3\pi)$, 0 and $1/(5\pi)$ spaced $2\pi/P_x$ apart. A two-dimensional mask with rectangular openings with line equal space can be thought of as the product of line equal space gratings in x and y directions.

a) Find the period of the grating in x for which the angle of the first diffracted order is symmetrical to the incident beam giving an infinite depth of focus. Find the image contrast.

b) Construct a wave-space sketch of the magnitude and location of the diffracted orders passing through the pupil for a two-dimensional mask with a period in x equal to that from part a) and a period in y that is twice as large.

c) Find the contrast and depth-of focus when a line equal space grating in x with twice the period of that in part a) is used. To calculate DOF assume that a lateral shift of ¼ of the period of the mask in part a) is allowed (1/8 of the mask in part c).

3.2 Small Feature Limit

Use the approximate formulas on pp. 134-136 ARNL1 to calculate the following and then verify using simulation with SPLAT. Assume a wavelength of 248 nm and a NA of 0.5 with 'top-hat' illumination with a sigma of 0.3. The size of the square is 0.20 λ/NA by 0.20 λ/NA in all cases.

a) The intensity maximum at the wafer for a transparent square feature in a dark field.

b) The intensity maximum at the wafer for an opaque square feature in a clear field.

c) The intensity minimum at the wafer at nominal focus for a transparent defect with 120^o phase.

d) The worst case intensity minimum at the wafer for any focus for the defect of part c).

3.3 Defect Interactions With Features

Now Consider the square feature from problem 3.2 to be a defect adjacent to a 0.6 λ/NA transparent line and use the perturbation method of adding electric fields to estimate the linewidth change as follows.

a) Simulate the image without a defect and determine the line edge slope.

b) Use the 0.3 feature intensity value and the defect wafer intensity to find their individual electric fields. Combine these fields (coherently in phase) to estimate the total electric field and intensity at the line edge.

c) Using the slope from part a) and intensity change from b) estimate the linewidth change.

d) Find the linewidth change if the phase of the defect is 120^o.