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 # 2, Due Th, Sept 14th, 00

Reading for Week#2: "The Lithography Process and Basis Simulation Models," Notes by AR Neureuther. Skip resist sections (5.3-5.5) till later.

The simulations in this homework can be run over the web or through the use of the instructional computing facilities. For the web use the Explorer browser to go to the Lithography Analysis through Virtual Access (LAVA) website at **http://cuervo.eecs.berkeley.edu/Volcano/** and select "Applications" and then the "Basic Projection Lithography," "Basis Aberration Effects in Projection Printing," or "Pattern and Aberration Interaction."

2.1 Exposure-Defocus Trees and Size Compensation to Create Overlap.
Construct a Focus-Exposure Tree for 10% tolerance for a 400 nm line and space pattern and a 400 nm square contact. Assume a wavelength of 248 nm and a NA of 0.5 with 'top-hat' illumination with a sigma of 0.5. (These are the nominal parameters of the new ASML 90 in the Microfabrication Laboratory. Two points can be generated from a single intensity plot for a given focus. Defocus in steps of 0.1 um is suggested. The square can be run using "Pattern and Aberration Interaction" and making the adjacent feature zero width.) There is clearly a problem with little overlap of the process window for these two features. Show that by sizing the contact at 500 nm a much larger common process window simultaneously exists.

2.2 Modified Illumination Improvements and Feature Size Dependencies.
Construct a contrast versus feature size curve for the conditions detailed below. Assume a wavelength of 248 nm and a NA of 0.5.

- **a)** As a reference find the contrast for a line equal space pattern for sizes from 500 nm down to 200 nm in steps of 50nm.
- **b)** Now add either a L=2S or S=2L curve and comment on any 'dead-zones'. (Here L is a line of resist that is created by an opaque mask feature.
- **c)** Now add annular illumination with sigma_in = 0.5 and sigma_out = 0.8 for your choice of L=S, L=2S or S=2L. What feature size does this illumination help the most and why? Is the 'dead-zone' worse

3.1 Aberrations: Strehl Ratio and Image Spread.

Make a table of the peak intensity and sidelobe intensity at + and - 0.85 λ/NA from the central peak along the x-axis for the image of a 0.6 λ/NA by 0.6 λ/NA feature for no aberrations and for 0.1 waves of individual aberrations of spherical, coma, astigmatism, and distortion. (For convenience used normalized units of $\lambda = 0.5\ \mu m$, NA =0.5 so that $\lambda/NA = 1.0\ \mu m$ and $\lambda/(2NA)^2 = 1.0\ \mu m$. Use the "Pattern and Aberration Interaction" and make the adjacent feature zero width to get an isolated square.) Comment on the relative drop in peak intensity (Strehl Ratio).

Check your simulation by sketching the relative peak intensity of a small two-dimensional feature versus one of the aberrations out to 0.25 waves. The relative peak intensity is given by $I(z) = 1-(2\pi/\lambda)^2(\Delta\Phi)^2$. Here $(\Delta\Phi)^2$ is the RMS deviation from the average phase over the pupil.

$$\left(\Delta\Phi\right)^2 \equiv \frac{\int_0^1\int_0^{2\pi}\left(\Phi_P - \overline{\Phi}_P\right)^2 \rho \, d\rho \, d\theta}{\int_0^1\int_0^{2\pi} \rho \, d\rho \, d\theta} = \overline{\Phi}_P^2 - \left(\overline{\Phi}_P\right)^2$$

For defocus the phase at each point in the pupil versus defocus distance z is given by $\Delta\Phi = (\lambda/4)(z/RU)\rho^2$. Spherical, coma, astigmatism, and distortion are similar and vary as ρ^4, $\rho^2\cos\theta$, $\rho^2\cos^2\theta$ and $\rho\cos\theta$. By convention a 0.1 wave aberration has a peak (rather than peak-to-peak) variation of a tenth of a wavelength.