EECS 243 – Advanced IC Processing and Layout

Fall 2000 **Office Hours** **Prof. A. R. Neureuther,**
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Solution Homework Assignment # 2

2.1 Exposure-Defocus Trees and Size Compensation to Create Overlap.

The new basic aberration applet with defocus, wavelength and NA inputs sure helps. After running a case the intensities at 180 nm and 220 nm can be read. The initial dense line pattern had an intensity of 0.27. If we assume the exposure is 20 mJ/cm2 then the dose to print at the 0.35 level will be (20 x 0.27)/(0.35) = 14.6 mJ/cm2 etc. The resulting plus and minus 10 linewidth doses are as follows for 0, 0.5 um and 1.0 um defocus.
400 nm Dense 14.6 – 30; 13.5 - 21.6; 12.3 – 14.2:
400 nm Contact 12 – 20.7; 13.8 –24.5; 21.6 30.0: (The overlap is 14.6 –20.7; 13.8-21.6; none)
500 nm Contact 11.7 –20.8; 12.6-20.8; 15.4-20.7: (The overlap is 14.6 – 20.8; 13.5 – 20.8; none)
Comment a feature size of 300 nm would show much less overlap of focus dose regions.

2.2 Modified Illumination Improvements and Feature Size Dependencies.

The basic lithography applet can be used here as well. a) For dense lines the contrast is 100% down to 300 nm where it drops to 0.94 and then 0.85 at 250 nm and 0.40 at 200 nm. b) S = 2L has higher peaks and, surprisingly even lower minima. Thus S = 2L has nearly 100% contrast to 200 nm where it is 0.77. L = 2S naturally has lower minima and it has some difficulty attaining a decent brightness. Because the minima are good it has high contrast. Thus the extra width helps the contrast in both cases. c) Annular illumination will help most by driving the lens symmetrically for a period of about $\lambda/(2 \times 0.65 \times NA)$ or sqrt 2 larger if the usual quadrapole position is used instead of the position on the axis. Thus a period of from 540 nm down to 382 nm. The dense lines at 200 nm show an improved contrast of 0.61 that is up from 0.40. However they have a drop in contrast to 0.76 from the top hat contrast of 0.85 at 250 nm. S = 2L contrast is down somewhat at 80 for 250 nm and 68 for 200 nm. Also the peak value is slightly degraded into the 0.8 to 0.9 range even for 300 nm lines. L = 2S has its weak maximum strongly degraded to 0.61, 0.51 and 0.38 for 300, 250 and 200 nm features. Overall though there is a better balance of the intensity levels and contrast for the three feature types with the annular source studied.

2.3 Aberrations: Strehl Ratio and Image Spread.

The applet for pattern aberration interactions can be used. However it was hard to read with the cursor so a direct input into SPLAT and reading of the cut-line values is recommended. The table shows sqrt I for various waves of aberrations with peak to peak values of 0.2 waves. Silelobes are 15% of clear electric field.

Primary	Left SL	Center	Right SL
None	-0.079	0.817	-0.079
Defocus	+0.111	0.766	+0.111
Coma	-0.150	0.799	+0.032
Astigmati	+0.099	0.795	+0.099
Trefoil	-0.136	0.801	3 Fold
Spherical	+0.123	0.770	+0.123

For defocus with $\Phi_P = (\lambda/4)(z/RU)\rho^2$ the result is $(2\pi/\lambda)^2(\lambda z/4RU)^2[1/3 - (1/2)^2] = 0.2056$. Thus for z = RU defocus the Strehl ratio is 0.7944. For 0.1 wave defocus in table peak to peak is 0.2 waves and the Strehl ratio is 1 – 0.132 = 0.868. Table = $(0.766/0.817)^2 = 0.879$.