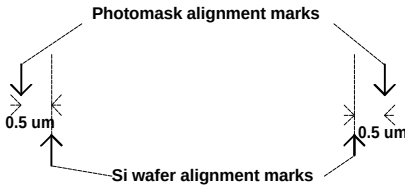
HW#5 Solutions

Problem 1



$\Delta L = L \times \Delta T\ (\alpha_{glass} - \alpha_{Si})$

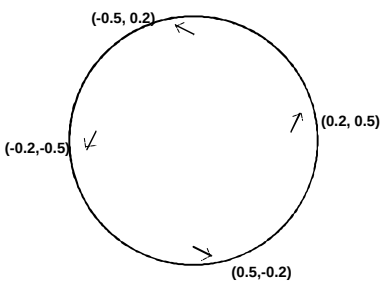
Maximum run in/out error = ± 1.0 μm with respect to the alignment marks on wafer => Δl = ±2 μm on photomask

$$\therefore\ \Delta T_{maximum} = \frac{\pm 2 \times 10^{-4}\text{cm}}{20\text{ cm} \times (9-2.3)\times 10^{-6}} = \pm 1.5°\text{C}$$

Problem 2

The center only has translational errors: 0.5 μm along x, -0.5 μm along y.
After substracting the translational error, we have:

	Top	Right	Center	Left	Bottom
x	-0.5	+0.2	0	-0.2	+0.5
y	+0.2	+0.5	0	-0.5	-0.2



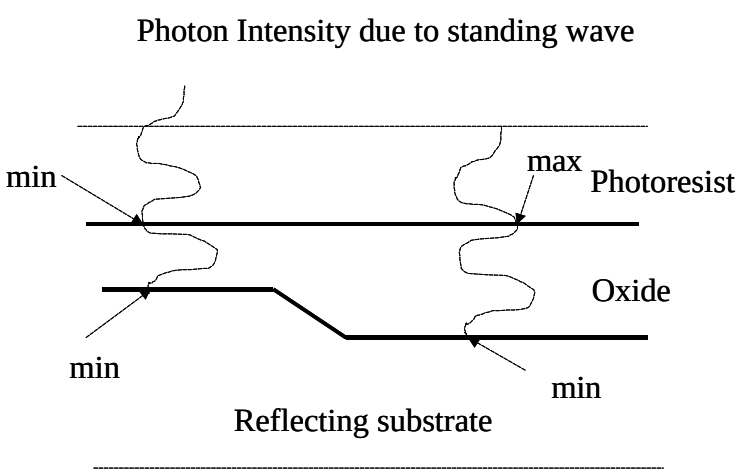
The run out error is 0.2 μm

The rotational error is 0.5 μm (counter-clockwise)

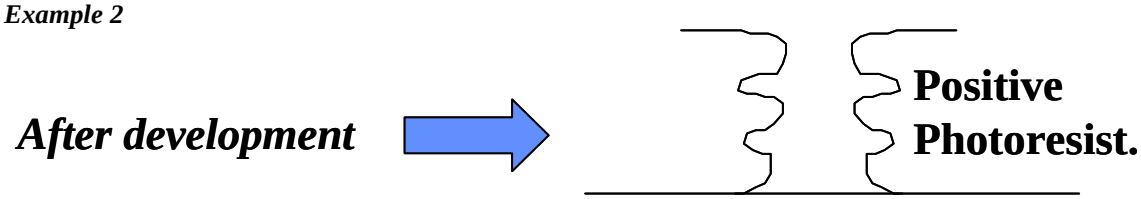
Problem 3

(a) ***Example 1***

For identical optical images, resist openings at the oxide/resist interface will have different sizes on thicker and thinner oxide regions. If the resist is used as the etching mask for oxide, we end up with different oxide feature sizes.

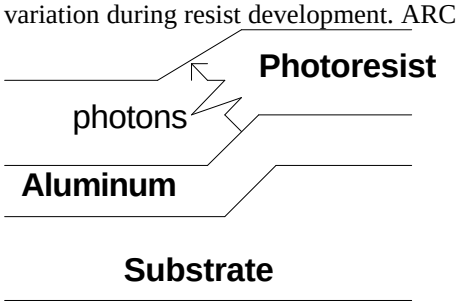


Example 2



- cross-section is schematic only

(b) (1)Light reflection from the slope can cause local increase of exposure which leads to linewidth variation during resist development. ARC reduces this reflection.



(2) Less reflected beam gives less standing wave effect, which gives also less variation of linewidth.
(3) Resist has more uniform thickness due to ARC layer planarization. The required development time can be more uniform. Less linewidth variation also.

Problem 4

From k • (0.436/NA) =0.5 and 0.436/ $[2(NA)^2]$=1, we obtain NA=0.467 and k = 0.536

For Stepper A: R = 0.536 •0.365 / 0.6 = 0.326um -- does not meet R requirement
DOF = 0.365/ $[2 \bullet (0.6)^2]$ = 0.507um > 0.4 um – o.k.

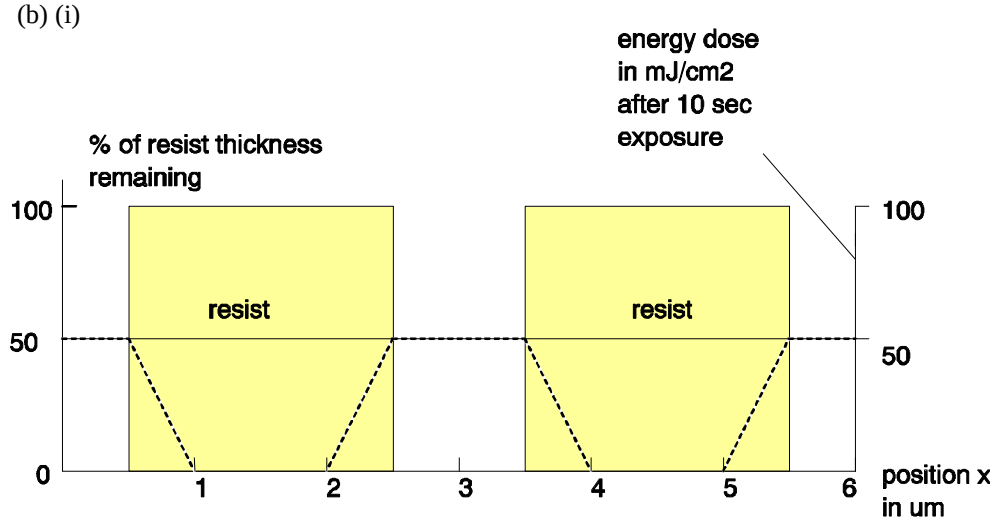
For Stepper B: R = 0.536 •0.248 / 0.5 = 0.266 um -o.k.
DOF = 0.248/ $[2 \bullet (0.5)^2]$= 0.496um > 0.4um - o.k.

Only Stepper B will meet both R and DOF requirements.

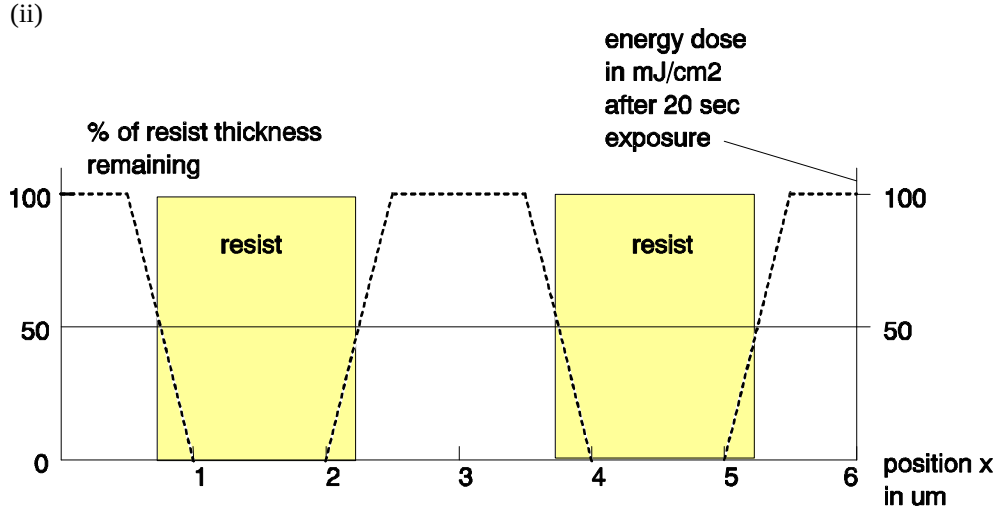
Problem 5

(a) The resist has infinite contrast.

(b) (i)



(ii)



Problem 6

(a)

Parameter	Desired Value (High, Low, or Depends)	Reason
λ/NA	Depends	Low λ/NA gives smaller printable feature but decreases DOF
Aerial Image contrast	High	Features still printable even with less resist contrast
Slope of aerial image intensity versus position	High	Steeper slope for developed resist pattern
Resist Contrast	High	Steeper slope for developed resist pattern
Resist Sensitivity	High	Higher throughput
Resist optical absorption coefficient	Depends	High absorption reduces standing wave and proximity scattering effects. However cannot be too high to block photon penetratin o bottom of resist.

(b) E-beam lithography

Advantage: Very small beam spot (< 1nm), can define very small features. [However, the smallest feature patternable still is limited by electron scattering effects].

Disadvantages:

Low throughput – a serial writing process versus the parrallel writing process of optical lithography.

Proximity effect- Backscattered electrons from substrate material may affect critical feature size.