6-1 A 0.60-μm film of silicon dioxide is to be etched with a buffered oxide etchant of etch rate 750 Å min^{-1}. Process data shows that the thickness may vary up to 10% and the etch rate may vary up to 15%. (*a*) Specify a time for the etch process. (*b*) How much undercut will occur at the top of the film?

6-1. (a) With a total process variation of 25%, a safe etch time would be:

Worst case, standard over calculation

thick $\frac{\Delta}{}$ + $\frac{\Delta}{\text{etch}}$ = 10% + 15% = 25%

(6000 Å)(125%)/(750 Å/min) = $10\frac{\text{Å}}{\text{min}}$ worst T_e

(b) Undercut will be: or $\frac{6600}{637} = 10.35\,\text{min}$.

1/2 lateral etch = (750 Å/min)(10.35 min) = 0.77 μM. typical per edge (no overetch)

$\frac{1}{2} \times 750(1.15) \times 10.35 = 0.90$ μm worst case

6-2 A set of windows are to be etched in a silicon dioxide film of thickness 6000 Å. As patterned in the photoresist, the size of the windows is 6 μm square. (*a*) Find the dimension of the window, as measured at the top of the oxide, after ideal isotropic etching (i.e., no overetch). (*b*) Find the dimension of the window as measured at the oxide-substrate interface. (*c*) Find the average slope of the window edge. (*d*) Find the upper dimension, (*e*) the lower dimension, and (*f*) the average slope after 30% overetch.

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6-2. (a) Ideal etching removes 6000 Å of film and hence undercuts 2 × 6000 Å = 1.2 μM. The window is thus 7.2 μM wide at the top.

(b) At the oxide-substrate surface, there is no overetch and hence no undercut. The dimension is 6 μM. (c) 45°.

$\Delta x = x - a$

(d) assume etch is an arc connecting top undercut to bottom as a sphere (because isotropic etch). (Anisotropic creates a spherical etch pit)

∴ at top undercut is

$\Delta x_t = r_{\text{etch rate}} \Delta t = 0.6 \times (0.3)$

$= 0.78\,\mu m$

∴ size =

$6 + 2\Delta x = 6 + 2(0.78) = 7.56\,\mu m$

(e) at bottom assume smooth spherical undercut

$\Delta x_b = \sqrt{\Delta x_T^2 - h^2}$

$= \sqrt{(0.78)^2 - 0.6^2} = 0.50\ \mu m$

$\therefore$ size $\rightarrow 6.0 + 2(0.5) = 7.0\ \mu m$

(f) slope at (average)

$\tan\theta \simeq \frac{0.6}{0.78 - 0.5} = 2.14$

$\theta = 65°$

Slope at bottom $\Rightarrow \tan\phi = \frac{h}{\Delta x_b}$

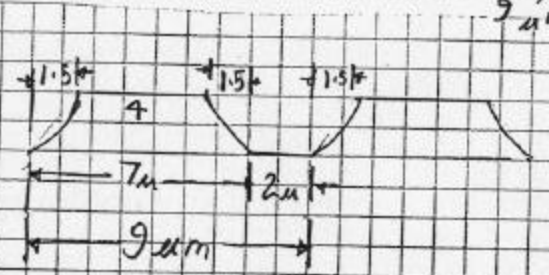
$= \frac{0.6}{0.5}$

$\phi = 50°$

6-4 In a memory device, the cells are accessed using an array of parallel metal lines. The pitch of these lines limits the size of the device. Determine the pitch of a set of parallel lines under the following conditions:
(*a*) The lines are made of aluminum, 1 μm thick.
(*b*) The minimum space-width resolvable with the photoresist technology in use is 2 μm.
(*c*) The lines are wet etched, isotropically, with a 50% overetch necessitated by uncertainties in etch rate and end-point detection.
(*d*) The minimum line dimension, after etching, at the top of the line, is required by design considerations to be 4 μm.

6-4. The minimum pitch is the sum of the minimum lead width at the top (4 μM), the minimum resolvable space (2 μM) and the undercut which equals 150% of the film thickness (1.5 μM); thus, on each edge

9 μm



6-6 In forming contact windows for a bipolar device, a single etch step is used to cut contacts through both the field oxide (6000 Å thick, etch rate 1000 Å min^{-1}) and through the emitter oxide (3000 Å thick, phosphorus-doped, etch rate 1500 Å min^{-1}). (*a*) Find the etch time required to clear the field oxide windows, with 20% overetch. (*b*) For this time, find the percentage of overetch and (*c*) the lateral undercutting per side for the emitter oxide windows.

6-6. (a) 120% (6000/1000) = 7.2 min. (b) 2 min/(3000/1500) = 10800

360% overetch. (c) (3000 Å)

$\frac{10800 - 3000}{3000} = 260\%$

10800 at top

was bottom value

$\Delta x = \sqrt{(\Delta x_T)^2 - h^2} = \sqrt{(1.08)^2 - (0.3)^2}$

$1\frac{1}{2} = 1.03\ \mu m$/side