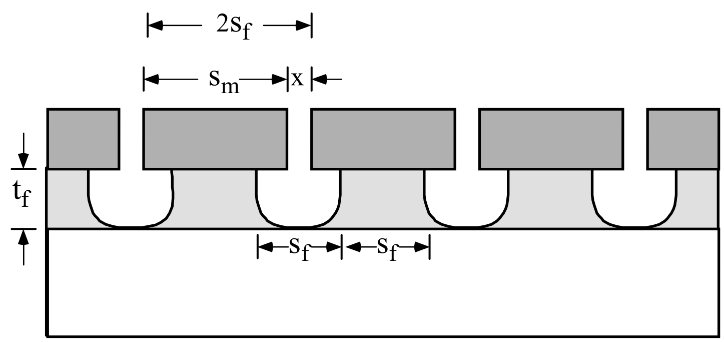
CHE323/384 Chemical Processes for Micro- and Nanofabrication
Chris Mack, University of Texas at Austin

Homework #9 Solutions

1. We are designing a process to produce aluminum metal lines of pitch 1.0 μm and height 0.5 μm. Assume that the metal linewidth and spacewidth are equal (that is, 0.5 μm each, as measured at the top of the metal lines). Since the etch process may have some etch bias, the resist pattern used can have a linewidth different from the spacewidth, though the minimum lithographic dimension (for either the line or the space) is 0.25 μm.
    a. What minimum degree of anisotropy is needed in an etch process in order to produce such a structure?
    b. What minimum pitch could be obtained for such a structure with wet etching? (Again with minimum lithograph dimension is 0.25 μm, metal thickness is 0.5 μm, and we want equal metal width and spacing as measured at the top.)



a. Metal pitch = $S_f + S_f = 1$ μm, or $S_f = 0.5$ μm. x = 0.25 μm, $t_f = 0.5$ μm

From the definition of anisotropy, A, $S_f = x + 2t_f(1 - A)$. Make sure you can derive this!
Thus, 0.5 = 0.25 + 2 (0.5) (1 - A) which leads to $A = 0.75$. (This could not be achieved by wet etching.)

b. If wet etching is used, we assume the degree of anisotropy is equal to 0.

Since $A = 0$, $S_f = x + 2t_f(1 - A) = x + 2t_f$

Thus, $S_f = 0.25 + 2\,(0.5)\,(1\text{-}0) = 1.25$ μm. The pitch equals 2 * S_f = 2.5 μm

2. In a particular etch process, which type(s) of dry etch equipment should be used?
    a. If selectivity is the biggest concern
    b. If the biggest concern is ion bombardment damage
    c. If the biggest concern is obtaining vertical sidewalls
    d. If the biggest concerns are selectivity and vertical sidewalls

e. We want it all: selectivity and vertical sidewalls and low ion damage, while maintaining a reasonable etch rate?

a. If biggest concern is selectivity? barrel or pure plasma

b. If biggest concern is ion damage? barrel or another remote plasma etching

c. If biggest concern is vertical sidewalls? sputtering or RIE

d. What about selectivity AND vertical sidewalls? RIE

e. If we want selectivity AND vertical sidewalls AND low damage, while maintaining a reasonable etch rate? A high density plasma version of RIE

3. Consider an isotropic etch with infinite selectivity. The film being etched has a nominal thickness *d*, but this thickness varies by ±30% due to topography. If a 50% overetch is used (that is, the etch time is set to be 50% longer than that required to just etch through the nominal film thickness) in order to ensure complete etching, what is the worst-case undercut distance?

For a 50% overetch, the undercut is 1.5d per side. Not that the maximum undercut is at the top of the film (just below the resist) and thus is independent of the actual film thickness.

4. When etching an oxide contact hole with a given process, the etch selectivity compared to photoresist is found to be 2.5. If the oxide thickness to be etched is 140 nm and a 50% overetch is used, what is the minimum possible photoresist thickness (that is, how much resist will be etched away)? For what reasons would you want the resist to be thicker than this minimum?

Let: R_{oxide} = oxide etch rate
R_{resist} = resist etch rate
t = time required to just etch the oxide, without overetch

Thus,

$$R_{oxide}\, t = 140\ nm \quad \text{and} \quad R_{resist} = \frac{R_{oxide}}{2.5}$$

For the 50% overetch, the etch time is 1.5t. Thus, the amount of resist etched away is

$$R_{resist}\left(1.5t\right) = \frac{1.5}{2.5} R_{oxide}\, t = \frac{1.5}{2.5} 140\ nm = 84\ nm$$

The absolute minimum resist thickness is 84 nm. The nominal thickness of the resist would need to be greater to account for variations in resist thickness (e.g., when coating over topography), resist etch rate (uniformity of etch in the chamber, loading effects, etc.), and the presence of horizontal etching components.