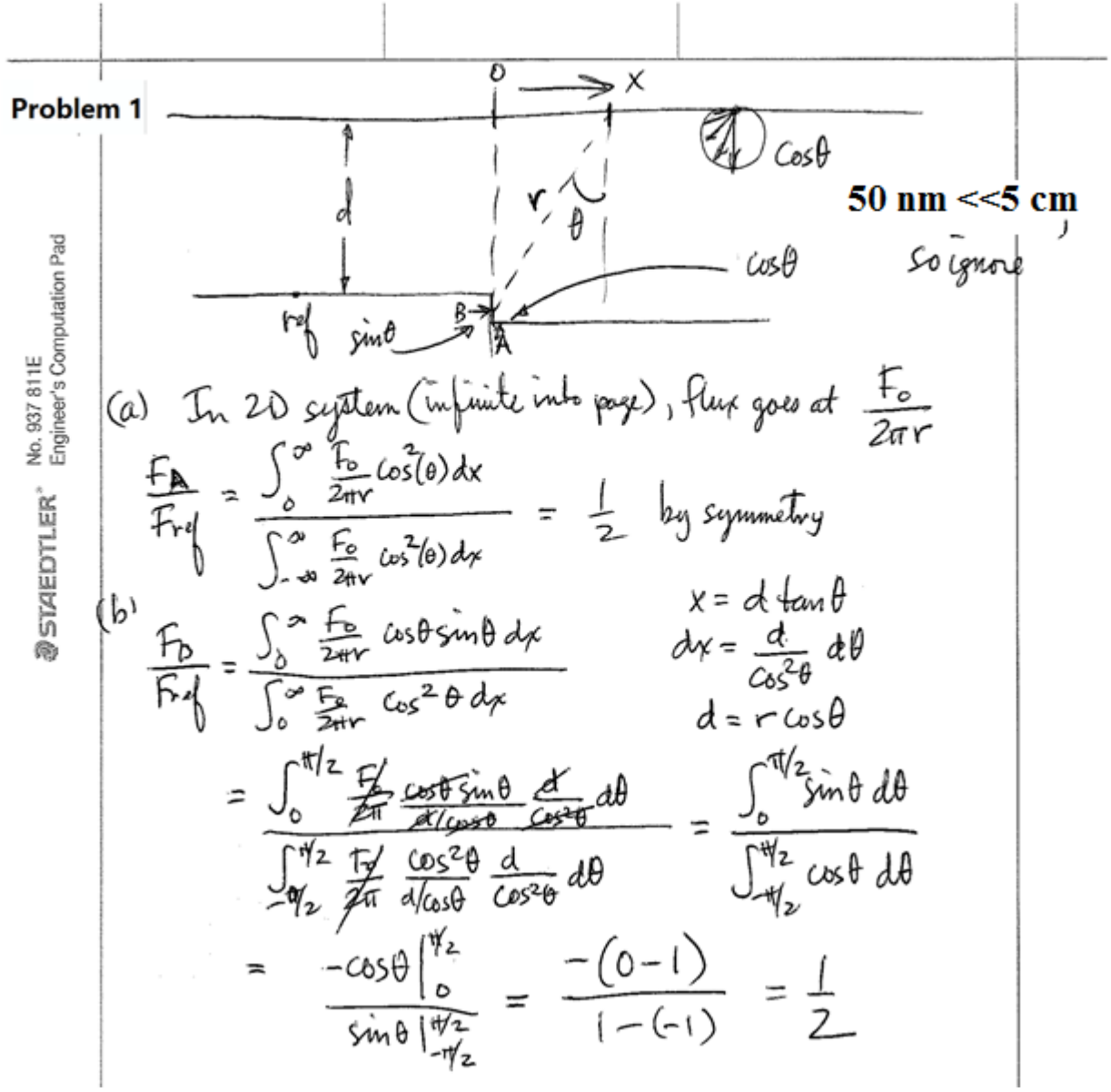
Homework #6 Solutions --- EE/MSE 486, Spring 2017



Problem 2:

a. If biggest concern is selectivity? barrel or remote plasma or wet etching

b. If biggest concern is damage? barrel or remote or wet

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

d. What about selectivity AND vertical sidewalls? RIE/HDP

e. What about selectivity AND vertical sidewalls AND damage, while maintaining reasonable etch rate? HDP

Problem 3

By Eq. 3 in the etching notes, A = 1- r_{lat}/r_{vert}. 0 .45 = 1- r_{lat}/r_{vert}. r_{lat}/r_{vert} = 0.55 (= amount of bias for each μm deep). The profile would look like Figure 10-3b.

For a linear etch mechanism we assume that the etch rate just equals the sum of the physical and chemical etching at each point following Eqn. 7, with no coupling between the physical and chemical components. The physical etching occurs only in the vertical direction and the (spontaneous) chemical etching occurs equally in both lateral and vertical directions (assuming that the physical etching is completely anisotropic, the chemical etching is perfectly isotropic, and the etch rate of each component is constant with time).

r_{lat}/r_{vert} = 0.55 = chem (lat) /[chem(vert)+phys(vert)].

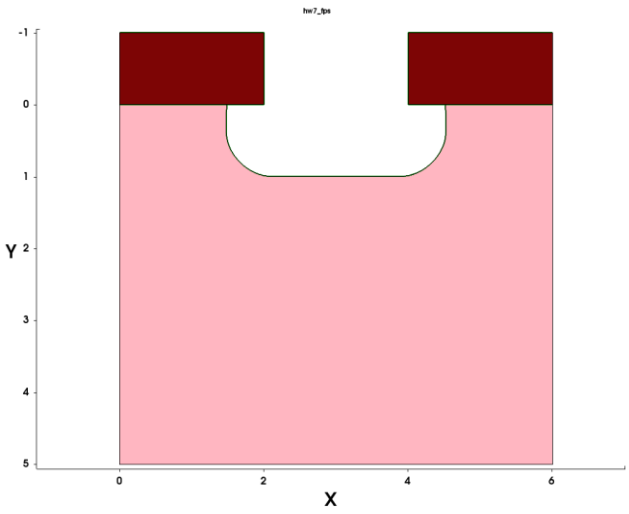
But chem(lat) = chem(vert), so

0.55 = chem (vert) /(chem(vert)+phys(vert))

0.55 = chem (vert)/ total(vert)

So the chemical etch component in the vertical direction = 0.55
and the physical etch component in the vertical direction= 0.45

Sentaurus input file is as follows:




```
line x  location=-1 spacing=0.01  tag=OxTop
line x  location=0    spacing=0.01  tag=SiDevTop
line x  location=0.5  spacing=0.01
line x  location=1 spacing=0.1
line x  location=5 spacing=0.5     tag=SiDevBot

line y  location=0    spacing=0.3   tag=Left
line y  location=2    spacing=0.05
line y  location=3    spacing=0.05
line y  location=4    spacing=0.05
line y  location=6    spacing=0.3   tag=Right

region silicon xlo=SiDevTop xhi=SiDevBot ylo=Left yhi=Right
region oxide   xlo=OxTop xhi=SiDevTop    ylo=Left yhi=Right

init concentration=1.0e15<cm-3> field=Boron

mask name=etch_mask left=2 right=4 negative
etch material = {oxide} type=anisotropic thickness=1<um> mask=etch_mask

beam name=src direction = {1 0 0} factor = 1
etch material = {silicon} type=fourier sources= {src} coeffs = {0.55 0.45}
time=1

grid remesh
struct tdr=hw7
```

Problem 4

In the vertical direction, the etch rate will have contributions from both the chemical and ionic etch components, but acting an a synergistic fashion. For the saturation/adsorption etch model (ion enhanced etching):

$$\text{Etch Rate} = \frac{1}{\text{density}} \frac{1}{\left(\frac{1}{K_i F_i} + \frac{1}{S_c F_c} \right)}$$

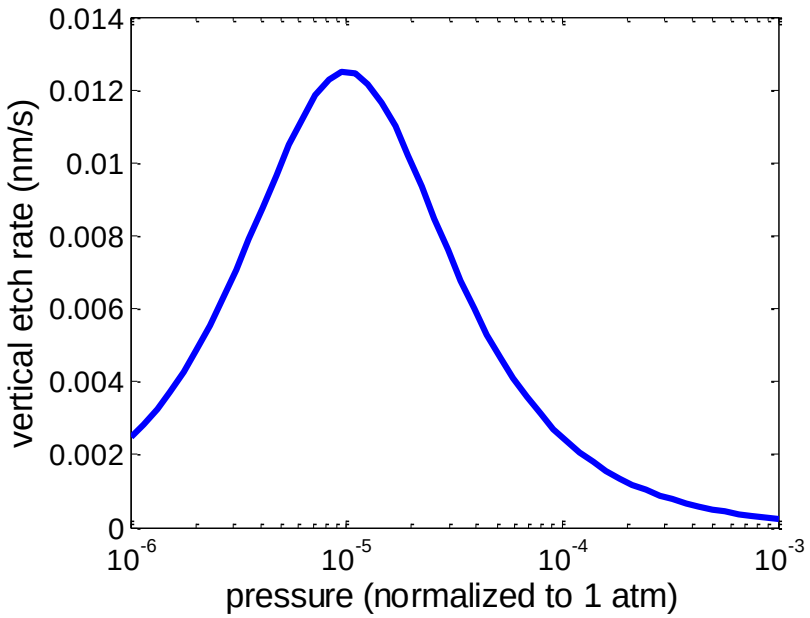
Plugging in $F_i = F_i'/P$ and $F_c = F_c' * P$, the density = 1 atom/nm^3, and that $K_i F_i' = S_c F_c' = 1$ atom/nm^2/sec gives:

Etch rate

$$= \frac{1}{density} \frac{1}{\left(\frac{1}{K_i F_i'/P} + \frac{1}{S_c F_c' * P} \right)}$$

$$= \frac{1}{40\ atom/nm^3} \frac{1\ atom/nm^2/\sec}{\left(\frac{1}{10^{-5}/P} + \frac{1}{10^5 * P} \right)}$$

$$= \frac{1}{40\left(10^5 P + \frac{1}{10^5 P} \right)} nm/\sec$$



In lateral direction, ion flux F_i can be cosidered to be very small. As a result, the etch rate in lateral direction is close zero if we use saturation/adsorption etch model. Thus the anisotropy stays at 1 independent of the pressure.