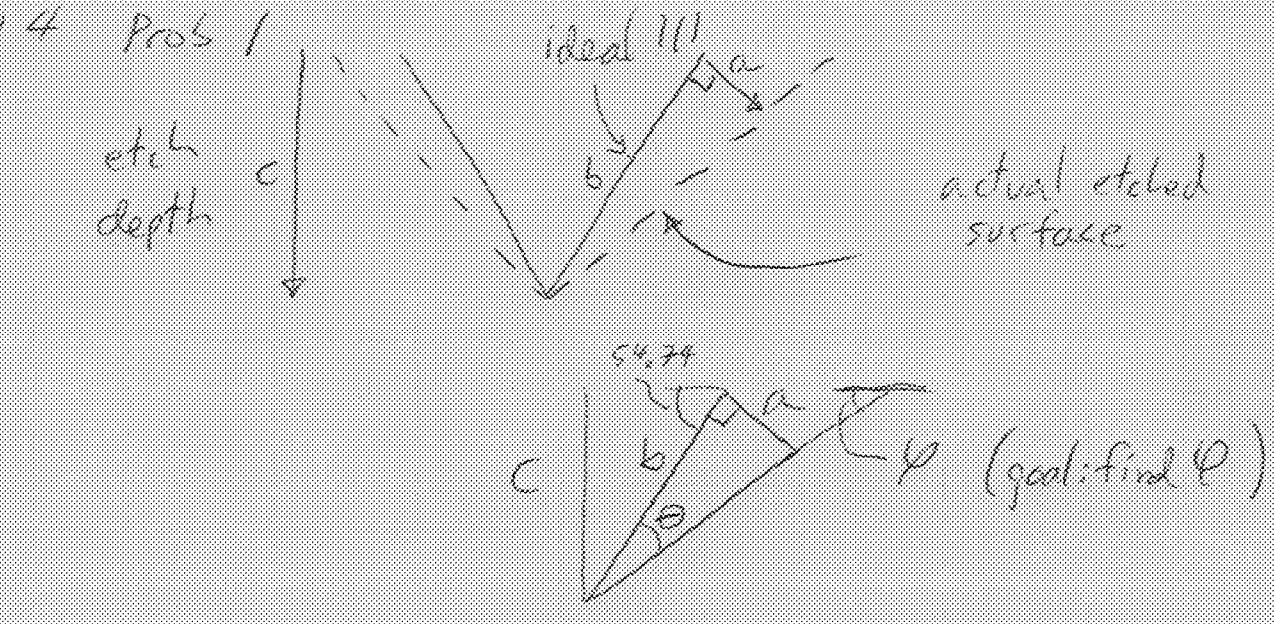
HW 4 Prob 1



$c = R_{100}\, t$

$a = R_{111}\, t$

$b = \frac{\sqrt{6}}{2} c$

$$\tan\theta = \frac{a}{b} = \frac{R_{111}\, t}{\frac{\sqrt{6}}{2} R_{100}\, t}$$

$$\theta = \tan^{-1} \frac{2}{\sqrt{6}} \frac{R_{111}}{R_{100}}$$

$$\varphi = \sin^{-1}\frac{\sqrt{3}}{2} - \tan^{-1} \frac{2}{\sqrt{6}} \frac{R_{111}}{R_{100}}$$

$$\approx 54.74^\circ - \left(\frac{60^\circ}{\text{rad}}\right) \frac{2}{\sqrt{6}} \frac{R_{111}}{R_{100}}$$

	$\frac{R_{111}}{R_{100}}$	φ
Ideal	0	54.74°
EDP	$\frac{1}{20}$	52.29°
KOH	$\frac{1}{400}$	54.6°
?	$\approx \frac{1}{5}$	45° ← useful if you could do it repeatably

to get 45°:

$$\frac{R_{14}}{R_{100}} = \frac{54.74 - 45}{60\,\frac{2}{\sqrt{6}}}$$

HW 4 pro 2

110 family intersections

$\left.\begin{matrix} 110 \\ \bar{1}\bar{1}0 \\ \bar{1}10 \\ 1\bar{1}0 \end{matrix}\right\}$ perpendicular to z-plane

$$110 \cdot \bar{1}10 = \sqrt{2}\sqrt{2}\cdot\cos\theta_{110}$$

$$0 = 2\cos\theta_{110}$$

$$\theta_{110} = 0$$

$$-2 = 110 \cdot \bar{1}\bar{1}0 = \sqrt{2}\sqrt{2}\cos\theta_{\bar{1}\bar{1}0}$$

$$\theta_{\bar{1}\bar{1}0} = \pm\pi$$

$$110 \cdot 011 = 1 = 2\cos\theta_{011}$$

$$\theta_{011} = \frac{\pi}{6}$$

$$110 \cdot 0\bar{1}1 = -1 = 2\cos\theta_{0\bar{1}1}$$

$$\theta_{0\bar{1}1} = \frac{2\pi}{6}$$

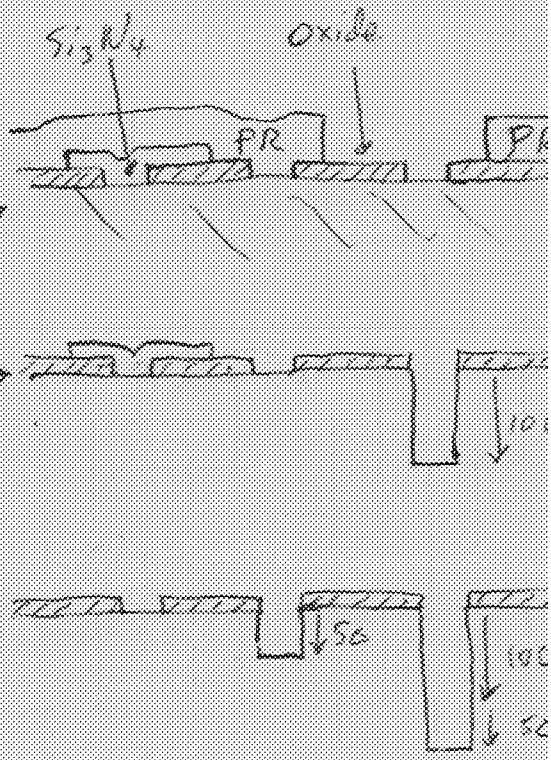
HW # 3

Goal: 50, 100, 200 μm deep trenches
w/ vertical sidewalls

Soln: use 3 masks and STS/DRIE etcher.

But need to do all lithography first
since we can't spin resist onto a wafer w/
deep trenches.

E.g.: thermal oxide / T50
Si_3N_4 LPCVD / T100
PR / T200



DRIE 100μm
strip PR

DRIE 50μm
etch nitride in hot phosphoric →
DRIE 50μm

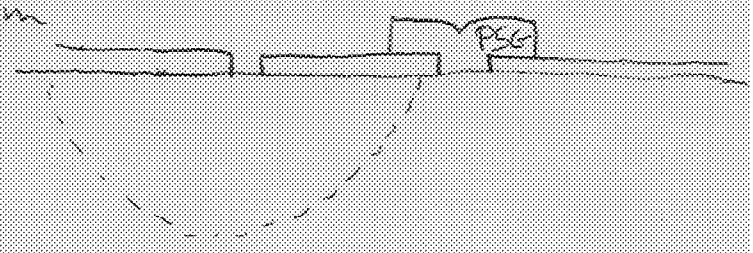
⇒ the oxide mask defines all of the trenches,
and the nitride and PR masks block them
at different times.

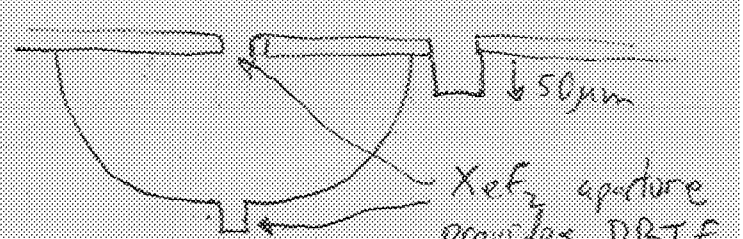
Alternate masks: oxide, aluminum, PR
aluminum, polyimide, PR
thermal oxide, PSG, PR
↳ need a timed HF etch to strip
PR and not thermal ox.
Not too hard, since etch rates
differ by 25×

HW 4 #4

Goal: 400μm deep ~ hemispherical cavities
50μm deep square trenches.

Soln 1: LPCVD nitride / HEMI HOLE + TRENCH
LPCVD PSG / TRENCH-COVER
XeF_2 timed etch 400μm (or other isotropic Si etchant)
strip PSG
STS DRIE 50μm





XeF_2 aperture provides DRIE access. Not exactly what we want.

Soln 2: maybe can etch trenches first, then spin resist to mask XeF_2. Trenches will create streaks & lumps in PR, making expose/develop difficult, but since the trenches can be 400μm from the XeF_2 etch hole, it might work.