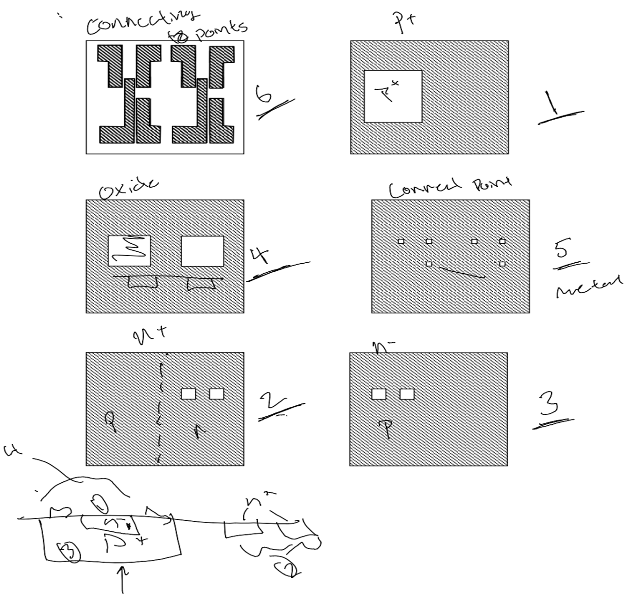
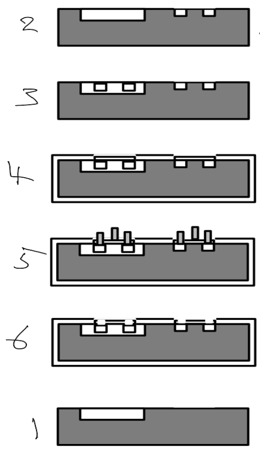
1. Our process flow uses 6 masks to produce NMOS and PMOS devices. Label the first mask, the first cross-section results and the first step with 1. Continue for all six steps.

P+: Source & Drain	N+: Source & Drain
N-: n-well	Metal
Via Contacts	Gate Oxide





$X_{ox} = \frac{-A + \sqrt{A^2 + 4(B)(t+\tau)}}{2}$

$D = D_0 e^{\frac{-E_A}{kT}}$

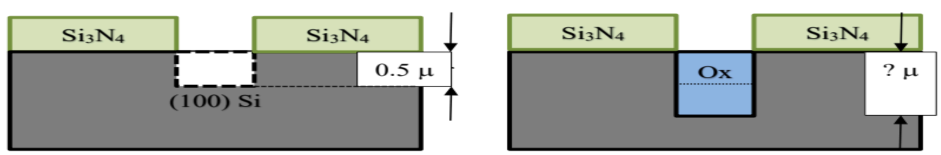
$t = \frac{x_o^2}{B} + \frac{x_o}{B/A}$

$X_o = \frac{A}{2}\left[-1 + \sqrt{1 + \frac{4B}{A^2}(t+\tau)}\right]$

$$\text{Dry} = \tau = \frac{x_i^2}{B} + \frac{x_i}{B/A}$$ ← dry

2. Local Oxidation is a process that is used to electrically isolate devices on an integrated circuit by growing oxide between devices. It is desirable to end up with a planar surface. The silicon nitride acts as a diffusion barrier for the water vapor. A trench is formed by removing 0.5 microns of silicon. (Below left side.)

WET DRY



$D = D_0 e^{\frac{-E_A}{kT}}$

a. How thick will the final oxide be to get a planar surface? (Above right side)
b. How long will it take to grow this oxide at 1000°C in a wet oxidation process? (Table at end of exam)

$.5\mu = (.54)X_{ox}$

$X_{ox} = \frac{.5}{.54} = .926\mu$

$t = \frac{x_o^2}{B} + \frac{x_o}{B/A} - \tau$ → 0 for wet Process

from table

$\frac{B}{A} = 9.7 \times 10^7 \mu/hr \; \exp\left(\frac{-2.05\,eV}{k\,(1000+273K)}\right)$

$= .7424\ \mu/hr$ $k = 8.61 \times 10^{-5}\,eV/K$

$B = 386\,[\mu^2/hr]\exp\left(\frac{-0.78\,eV}{kT}\right)$

$= .3151\,[\mu^2/hr]$

$t = \frac{.926^2}{.3151} + \frac{.926}{.7424} = 3.97\text{hrs} \approx 4\text{hrs}$

X_{ox} = ______________________________ (μ)

B/A = ______________________________ (μ/hr)

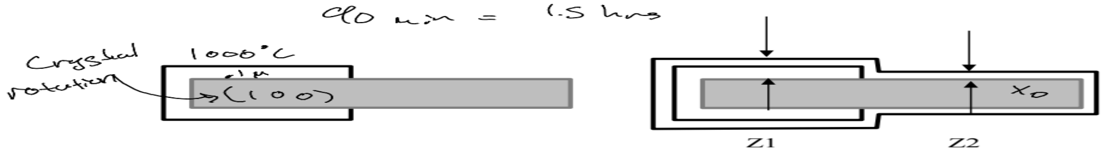
B = ______________________________ (μ^2/hr)

Wet → τ = ______ 0 ______ (hr)

Wet Oxidation time (hrs:min) ____________________

3. Oxidation thickness: You grow oxide with a thickness 0.1 microns using a dry process at 1000 °C. You then remove the oxide from half of the wafer (Below left). Finally, you put the wafer in a wet oxidation process for 90 minutes at 900 °C. What is the final thickness of the oxides with and without the initial oxide (Below right)?

90 min = 1.5 hrs



90 min @ 900°C wet   Coefficient from table

$\frac{B}{A} = 9.7\times10^7 \exp\left[-\frac{2.05}{kT}\right] = 0.1509\,[\mu/hr]$

$B = 386 \exp\left[\frac{.78}{kT}\right] = .1719\ \mu^2/hr$

$\tau = \frac{(0.1\mu)^2}{.1719\ \mu^2/hr} + \frac{.1\mu}{.1509\ \mu/hr} = 0.7209\ hr$

$A = \frac{B}{B/A} = \frac{.1719\ \mu^2/hr}{.1509\ \mu/hr} = 1.1392\ \mu$

$Z_1 = \quad x_o = \frac{-A + \sqrt{A^2+4B(t+\tau)}}{2} = .1935\,\mu = x_{o1}$

$Z_2 \quad x_o = \frac{-A + \sqrt{A^2+4B(\overset{1.5\,hr}{t} + \overset{\to 0\,min}{\tau})}}{2} = .2708\,\mu = x_{o2}$

B/A = .1509 (μ/hr)

B = .1719 (μ²/hr)

A = 1.1392 (μ)

τ = 0.7209 (hr)

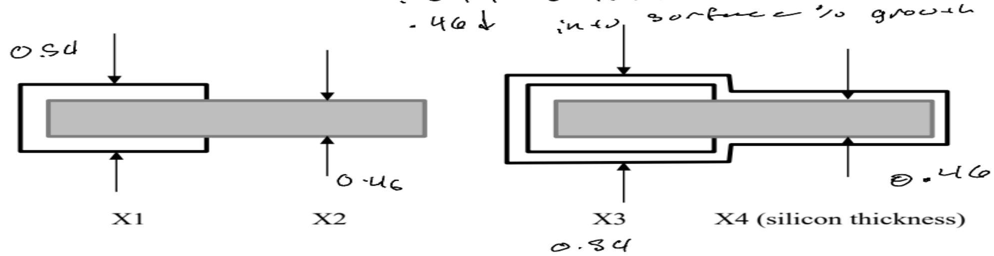
Z1 : Oxide thickness (μ) .1935 with first step oxidation

Z2 : Oxide thickness (μ) .2708 μ **without** first step oxidation

How long can grow it to keep in spec

4. Wafer thickness: Calculate the following dimensions from the above processing of problem 3. Assume the wafer initially was 100 microns thick:

.54 ↑ out of surface % growth up
.46 ↓ into surface % growth in



X1 = 100.108 XXX.XXXX (μ) $100\mu + .1(.54)2 = 100.108\,\mu$

from Problem statement

X2 = 99.908 XXX.XXXX (μ) $100\mu - .1(.46)(2) = 99.908\,\mu$

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Z_1

X3 = 100.2975 XXX.XXXX (μ) $100 + .2708(.54)(2) = 100.2975$

Z_2

X4 = 99.73μ XXX.XXXX (μ) $99.908 - .1935(.46)(2)$

$= 99.73\,\mu$