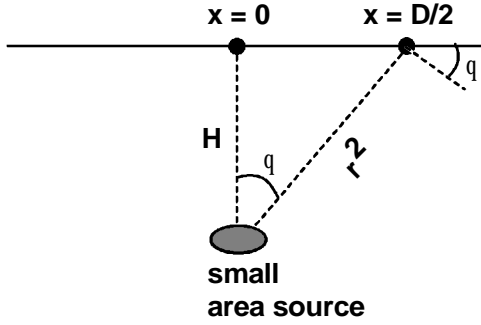


Problem 1



(a) Let flux at $(x = 0) = \frac{F}{H^2} \therefore$ Flux at $(x = \frac{D}{2}) = F \cos \theta / r^2$

\therefore Deposition rate / unit wafer area = $\frac{F}{H^2}$ at $x=0$

Deposition rate / unit wafer area = $\frac{F \cos \theta}{r^2} \cdot \cos \theta$ at $x = \frac{D}{2}$

$\therefore \frac{\text{thickness}(x = \frac{D}{2})}{\text{thickness}(x = 0)} = \cos^2 \theta \cdot \frac{H^2}{r^2} = \frac{1}{[1 + (\frac{D}{2H})^2]^2}$

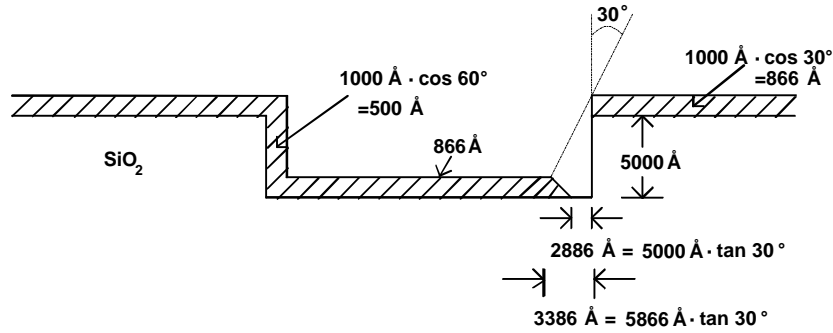
(b) For small planar source, $\frac{\text{thickness}(x = \frac{D}{2})}{\text{thickness}(x = 0)} = \cos^2 \theta \cdot \frac{H^2}{r^2} = \frac{1}{[1 + (\frac{D}{2H})^2]^2} = \frac{0.54}{0.6}$

For $D=300\text{mm}$, **H (min) = 652 mm.**

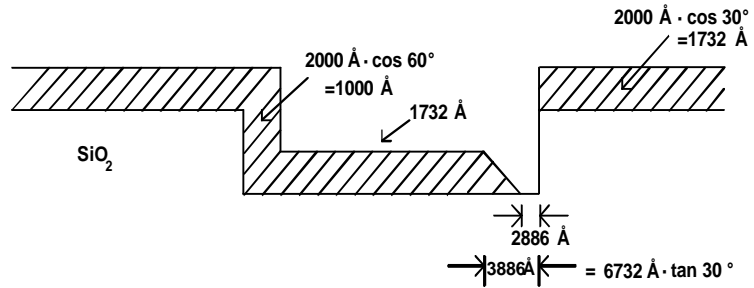
Problem 2

The corner profiles shown in sketches are approximate only. The exact shape depends on the initial roundness of the corners.

a.) After 1min:

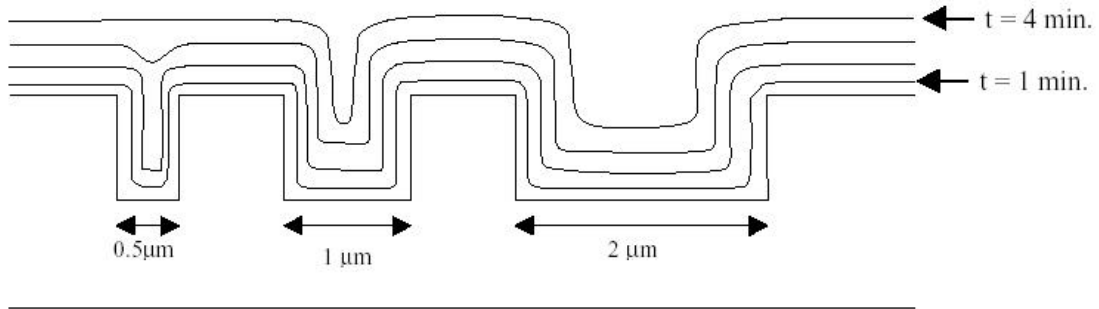


b.) After 2min:



Problem 3

(a)



(b) For conformal deposition, **less** deposition thickness is needed to planarize high aspect ratio (large height /narrow width) trenches.

Problem 4

Process Description

1) Starting material, Si substrate

Cross Section

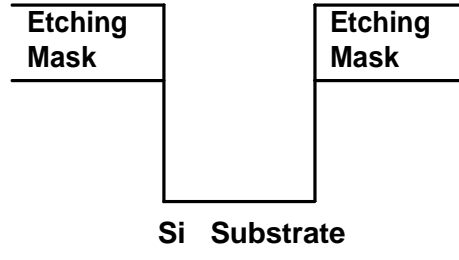
Si Substrate

2) Pattern mask for trench etching (Mask #1).
The etching mask material can be photoresist or any suitable thin film (e.g. Si_3N_4 , SiO_2 etc..)

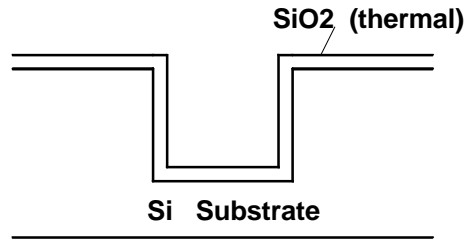


Si Substrate

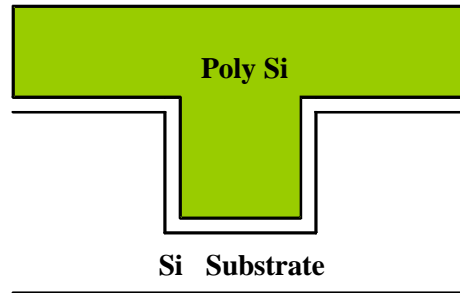
3) Anisotropic etching of trench in Si (e.g. reactive ion etching)



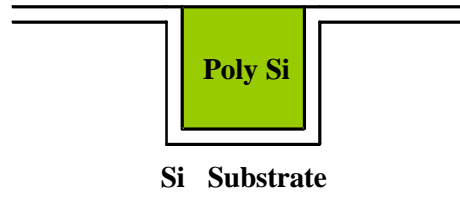
4) Strip masking material
Thermal oxidation



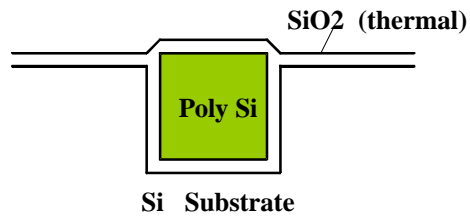
5) Conformal deposition of poly-Si until surface is planar



6) Etch poly-Si to SiO₂ position



7) Thermal oxidation



Problem 5

(i) With small flow rates, deposition rate is limited by gas transport, Grove model \Rightarrow

$$F_1 \equiv D_G \cdot \frac{C_G - C_S}{\delta} \Rightarrow h_G = \frac{D_G}{\delta} \text{ where } D_G = \text{diffusivity}$$

$$\frac{dy}{dt} \propto h_G \propto \frac{1}{\delta} \propto \sqrt{U}$$

(ii) With high flow rates, deposition rate is limited by surface reaction with $dy/dt \propto k_s$ which is independent of flow rate.

(iii) For small flow rates, deposition rate is limited by gas transport. From Grove model,

$$dy / dt \approx h_G \frac{C_G}{\rho}$$

At a growth rate of $0.1 \mu\text{m} / \text{minute} = 1.67 \times 10^{-7} \text{ cm/sec}$.

$$h_G = 1.67 \times 10^{-7} \times \frac{5 \times 10^{22}}{4 \times 10^{16}} = 0.208 \text{ cm/sec}$$

(iv) Using a higher flow rate with same pressure will supply more reactant gas /unit time into the CVD reactor. Mass depletion due to consumption of reactants will be less severe.