ENSC 495/851 Tutorial 2 Mar. 10, 2014

1. A <100> silicon wafer is oxidized twice during an IC process. Find the total thickness of the silicon dioxide in the field (which received both oxidations) after the following furnace steps are carried out in this sequence.
(i) At 1100°C for 40 min in dry oxidation
(ii) Followed by 1000°C for 120 min in wet oxidation
For each of these do the calculations twice. (a) using the charts in the notes, but extrapolate if needed for times (4 marks).
(b) Use the A and B parameters and a full calculation to compare the theory to the actual furnace values. (5 marks)

Solution
(a) Using the charts from lesson 2 then for
(i) Start at 1100°C for 40 min (= 0.667 hr) in dry oxidation
which gives 0.100μm of oxide on the dry oxide chart (1 mark)

(ii) Followed by 1000°C for 120 min (= 2.000 hr) in wet oxidation
First must convert the 0.100μm of dry oxide into the τ for the wet oxide. From wet oxide chart this gives τ = 0.130 hr of wet oxide.
Thus the new growth is

$$t+\tau = 2.000 + 0.130 = 2.130 \text{ hr}$$

of wet oxide. From the wet oxide charts this gives 0.580 μm of final oxide (3 marks)

(b) Using the full Grove growth formula

$$x_o^2 + Ax_o - B(t+\tau) = 0$$

(i) Start at 1100°C for 40 min = 0.667 hr in dry oxidation
A = 0.090 μm, B = 0.027 μm^2/hr, B/A = 0.300 μm/hr, τ = 0.067 hr

$$t + \tau = 0.667 + 0.067 = 0.734 \text{ hr}$$

$$x_0 = \frac{-A + \sqrt{A^2 + 4B(t+\tau)}}{2} = \frac{-0.090 + \sqrt{0.090^2 + 4x0.027(0.734)}}{2} = 0.103\ \mu m$$

(2 marks)

(ii) Followed by 1000°C for 120 min (= 2.000 hr) in wet oxidation
A = 0.226 μm, B = 0.287 μm^2/hr, B/A = 1.270 μm/hr, τ = 0.000 hr
Again must convert the 0.103μm of dry oxide into the $\tau_{wet\text{-}dry}$ for the wet oxide.

$$\tau_{wet-dry} = \frac{x_0^2 + Ax_0}{B} = \frac{0.103^2 + 0.226x0.103}{0.287} = 0.118\ hr$$

Now get the total equivalent time of wet oxidation (note $\tau_{wet\text{-}dry}$ includes any initial τ for that growth)

$$t + \tau_{wet\text{-}dry} = 2.000 + 0.118 = 2.118 \text{ hr}$$

$$x_0 = \frac{-A + \sqrt{A^2 + 4B(t+\tau)}}{2} = \frac{-0.226 + \sqrt{0.226^2 + 4x0.287(2.118)}}{2} = 0.675\ \mu m$$

Thus the combined total thickness of both oxidations is 0.675 μm. (3 marks)