

# 1 Profiles & Layout

1.1

1.2

1.3

# 2 Process Procedures

2.1

2.2

2.3

# 3 Calculations

a) Film Thickness

Layer	Theoretical calculation (nm)	Experimental (nm)	% Error	Linewidths (photoresist) (nm)	Linewidths (after PR Strip) (nm)	% Overetch
Field Oxide	505.8	477.2	5.65	?	3000	?
Polysilicon	?	?	?	?	?	?
Gate Oxide	80.1	86.5	7.40	3628	4000	?
Intermed Oxide	386.3	320	17.2	?	?	?
Aluminum	?	?	?	2088	2520	?

b) Sheet Resistance

c) Overetch

1) Theoretical and experimental thicknesses of field oxide, gate and intermediate oxides (Include orientation dependence of oxidation rate but not impurity dependence) (9 points)

For details on the theoretical oxide thickness calculations see Appendix 5.1.

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Gate Oxide	80.1	86.5	7.40
Intermed Oxide	386.3	320	17.2

# 4 Questions

1. The lab uses positive photoresist. The lithography machine uses a light that has g line wavelength. The I and G lines refer to the wavelength of the light coming off the light bulb that reacts with photoresist. G line is roughly xx wavelength and I line is xx wavelength.

# 5 Appendix

## 5.1 Oxide Thickness calculations

Film thickness calculation for oxides:

$$X_{ox} = \frac{0.5B}{B/A} \left[ \sqrt{1 + \frac{4}{B} \left(\frac{B}{A}\right)^2 (t + \tau) - 1} \right] \quad (1)$$

$$\tau = \frac{X_i^2}{B} + \frac{X_i}{B/A} \quad (2)$$

where

$$B/A = D_o e^{\frac{-E_a}{kT}} \text{ (Use table 3.1 [1] to find } E_a \text{ and } D_o)$$

$$B = D_o e^{\frac{-E_a}{kT}} \text{ (Use table 3.1 [1] to find } E_a \text{ and } D_o)$$

$$t = \text{Time of oxide growth}$$

$$\tau = \text{Time of initial oxide growth already present}$$

$$X_i = \text{length of initial oxide growth}$$

Example: Calculated oxide thickness of Intermed Oxide:

Given: 5 min dry oxidation at 1050°C and 12 + 25 min wet oxidation and annealing at 1050°C, calculated oxide growth.

First we consider the 5 min dry oxidation. Using table 3.1 [1] for a  $< 100 >$  Silicon, and using dry oxidation, we see that for the linear rate constant ( $B/A$ ),  $E_A = 2.00$  eV and  $D_o = 3.71 \times 10^6 \mu\text{m/hr}$ . For the parabolic rate constant ( $B$ ),  $E_A = 1.23$  eV and  $D_o = 772 \mu\text{m}^2/\text{hr}$ .

Using an arrhenius equation where  $k$  = Boltzmann's constant, and  $T$  = temperature.

$$B/A = D_o e^{\frac{-E_A}{kT}} = 3.71 \times 10^6 e^{\frac{-2.00 * 1.602 \times 10^{-19}}{1.38 \times 10^{-23} (1050^\circ\text{C} + 273)}} = 0.0887 \mu\text{m/hr}$$

$$B = D_o e^{\frac{-E_A}{kT}} = 772 e^{\frac{-1.23 * 1.602 \times 10^{-19}}{1.38 \times 10^{-23} (1050^\circ\text{C} + 273)}} = 0.0159 \mu\text{m}^2/\text{hr}$$

Since there is no initial oxide here,  $\tau = 0$ ,

$$X_{ox} = \frac{0.5B}{B/A} \left[ \sqrt{1 + \frac{4}{B} \left(\frac{B}{A}\right)^2 (t + \tau)} - 1 \right] = \frac{0.5(0.0159)}{0.0887} \left[ \sqrt{1 + \frac{4}{0.0159} (0.0887)^2 \left(\frac{5\text{min}}{60\text{min/hr}} + 0\right)} - 1 \right] \approx 7.11 \text{ nm}$$

Now after this dry oxidation, we have a 37 minute wet oxidation at 1050°C. Using table 3.1 [1] again, but this time using the constants that apply for wet oxidation,

$$B/A_{\text{wet}} = D_o e^{\frac{-E_A}{kT}} = 9.70 \times 10^7 e^{\frac{-2.05 * 1.602 \times 10^{-19}}{1.38 \times 10^{-23} (1050^\circ\text{C} + 273)}} = 1.50 \mu\text{m/hr}$$

$$B_{\text{wet}} = D_o e^{\frac{-E_A}{kT}} = 386 e^{\frac{-0.78 * 1.602 \times 10^{-19}}{1.38 \times 10^{-23} (1050^\circ\text{C} + 273)}} = 0.411 \mu\text{m}^2/\text{hr}$$

This time we do have an initial oxidation time  $\tau$  because of the dry oxidation we did. Here  $X_i$  is the oxide length we calculated for the dry oxidation growth,

$$\tau = \frac{X_i^2}{B_{\text{wet}}} + \frac{X_i}{B/A_{\text{wet}}} = \frac{0.00711^2}{0.411} + \frac{0.00711}{1.50} \approx 0.00488 \text{ hrs}$$

And finally our oxide growth is,

$$X_{ox} = \frac{0.5B}{B/A} \left[ \sqrt{1 + \frac{4}{B} \left(\frac{B}{A}\right)^2 (t + \tau)} - 1 \right] = \frac{0.5(0.411)}{1.50} \left[ \sqrt{1 + \frac{4}{0.411} (1.50)^2 \left(\frac{(12 + 25)\text{min}}{60\text{min/hr}} + 0.00488\text{hrs}\right)} - 1 \right] \approx 386.3 \text{ nm}$$