EE 330
Section 5
Homework 4

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This is just algebra busy work.
There is little learning being done here.

1) Area of wafer = $\pi(300/2)^2 = 70685.8mm^2$
Chips/Wafer: $70685.8/50 = 1413$ *chips*
Hours/Year: 365 $days/yr * 24\ hrs/day = 8760hrs$

248 nm Machine:
Wafers/Year: 80 $wafers/hr * 8760\ hr/yr = 700,800\ wafers/yr$

Cost/Wafer: $\$10M/700,800 = \$14.27$

Cost/Chip: $\$14.27/1413 = \$0.01$

193 nm Machine:
Wafers/Year: 20 $wafers/hr * 8760\ hr/yr = 175,200\ wafers/yr$

Cost/Wafer: $\$40M/175,200 = \$228.31$

Cost/Chip: $\$228.31/1413 = \$0.162$

Difference = $\$0.162 - \$0.01 = \$0.152$

2) Dielectrics: $SiO_2 = 3.9, HfO_2 = 25$. Thickness must be proportional to dielectric, therefore $t_{HfO_2} = 25/3.9 * 2 = 12.82nm$

3) Vol $SiO_2 = .044nm^3$ $25A \rightarrow 2.5nm$
$7nm * 14nm * 2.5nm = 245nm^3 = 5568$ *molecules*

4) Resistivity of Aluminum $= 2.8 * 10^{-8}\Omega m, \quad R = \frac{\rho * l}{w * t}$
$R_{Al} = \frac{(2.8*10^{-8})*(200*10^{-6})}{(60*10^{-9})*(60*10^{-9})} = 1555.5\Omega$

5) Silver. Expensive with high electron migration potential.

6) 300mm wafer thickness $= 775 \pm 25um$, $+150um$ for saw $= 925um$
$2m/(925 \pm 25um) = 2105 \rightarrow 2222$ wafers.

7) What is this.

8a) Length = 1um Width = 3um
b) Photoresist under-exposed $\rightarrow length = .8um$
A combination of both issues leaves width unchanged = 3um.
c) Width still unchanged, but now issues cancel out so length is unchanged so that length = 1um.

9) $\rho_{Al} = 2.8 * 10^{-8}\Omega m, \quad R = \frac{\rho * l}{w * t}$
t $= \frac{(2.8*10^{-8})*(250*10^{-6})}{(2*10^{-6})*25} = .14um$
Sheet Resistance $= \frac{\rho}{t} = \frac{2.8*10^{-8}}{.14*10^{-6}} = .2\Omega$

10) $\rho_{Cu} 1.68 * 10^{-8}\Omega m, \quad R = \frac{\rho * l}{w * t}$
$l = \frac{(2*10^{-6})*(.14*10^{-6})*25}{(1.68*10^{-8})} = 417um$

11) Thermal silicon growth uses silicon from substrate, approx .47x full height of oxide. Therefore, if oxide is 5000A, W_{height} increase is $5000 * (1 - .47) = 2650A$

12) Sheet resistance given, $R_{poly} = 23.2\ \Omega/sq\ somethings$ (thanks for leaving that blank btw, very helpful), and $R_{p+} = 106.7\ \Omega/sq\ somethings$.
As the units are conveniently obfuscated, I will be assuming they are *sq um*.

5k resistor: Poly $\rightarrow 5000/23.2 = 215.52um$ len,
P+ $\rightarrow 5000/106.7 = 46.86um$ len.
Min size Poly = .2um x .2um, Min size P+ = .3um x .3um
Min Poly serpentine $= .2 * .2 * 215.52 = 8.62um^3$.
Min P+ serpentine $= .3 * .3 * 46.86 = 4.22um^3$.
$8.62/4.22 \rightarrow 2.04x$ area increase if using Poly.