EE 330
Homework 1 Solutions
Fall 2020

Problem 1

Transistor Area without Overhead = $A'_T = 7nm * 7nm = 49nm^2$
Transistor Area with Overhead = $A_T = A'_T * 10 = 490nm^2$d
Wafer Radius = $R_w = \frac{12in}{2} = 6in = 1.524 * 10^8 nm$
Wafer Area = $\pi R^2 = \pi(1.524 * 10^8 nm)^2 = 7.297 * 10^{16} nm^2$
Die Area = $1750 * 490nm^2 = 857500nm^2$
Number of Die = $\frac{Wafer\ Area}{Die\ Area} = 85 * 10^9 \frac{dies}{wafer}$

Problem 2

$$\frac{Cost}{die} = \frac{3500\frac{\$}{wafer}}{85*10^9\frac{dies}{wafer}} = 4.12 * 10^{-8} \frac{\$}{die}$$

Problem 3

Assuming ink drop diameter is 100μm:
Area of an ink drop = $A_{Ink} = \pi\left(\frac{100\mu m}{2}\right)^2 = 7.854 * 10^{-9} m = 7.854 * 10^9 nm^2$
Number of transistors = $\frac{A_{Ink}}{A_{Transistor}} = \frac{7.854*10^9 nm^2}{490nm^2} = 1.6 * 10^7$

Problem 4

There are a number of reasons why it is more energy efficient to use multiple cores on a die operating at a lower frequency than to use a single core operating at a high frequency. The largest reasons are that the power dissipation of a circuit increases with operating frequency and that, if multiple cores are used, unnecessary cores can be deactivated. Deactivating unused cores saves a significant amount of power.

Problem 5

A silicon atom has an atomic diameter of approximately $210pm$, which is equivalent to $0.21nm$. This means that a $7nm$ transistor is approximately 33.33 times larger than a single silicon atom.

A silicon dioxide molecule has a diameter which is roughly equal to $1nm$. This means that a $7nm$ transistor is appromxiatly 7 times larger than a SiO_2 molecule.

Depending on a number of factors, the width of a human hair is approximately $100\mu m$. This means that a human hair is approximately 14,285 times larger than a $7nm$ transistor.

Problem 6

If your numbers don't match exactly, that is fine. The goal of this problem is to get estimates and to see the approximate size of Samsung to other large companies.
Samsung: $222 Billion

Intel: $33.1 Billion

Saudi Aramco: $355.9 Billion

Nestle $92 Billion

Problem 7

10nm

Problem 8

(a) $I = \frac{P}{V} = \frac{95W}{1.2V} = 79.2A$

(b) For a gold wire with ρ=1.16Ω/inch

$R = \rho L = 0.58\Omega$

$V = I * R = 45.9V$

(c) $P = I^2 R = 3638W$

(d) The fusing current for the defined bond wire $0.6A - 0.7A$. Ten percent of this is is 0.06A-0.07A

$$\# \, of \, wires = \frac{total \, current}{current \, per \, wire} = \frac{79.2A}{0.06\frac{A}{wire}} \sim \frac{79.2A}{0.07\frac{A}{wire}} = 1131 \sim 1320 \, wires$$

Problem 9-10

Type	**Storage Density (Bit/cm^2)**	**Cost of Storage ($/bit)**	
CD	10^7	10^{-11}	
DVD	10^8	10^{-12}	Lowest
Blue Ray	10^9	10^{-12}	Lowest
Hard Disk	10^{10}	10^{-12}	Lowest
SRAM	10^7	10^{-6}	Highest
DRAM	10^9	10^{-9}	
FLASH	10^{10}	10^{-10}	

$$Ratio = \frac{10^{-6}}{10^{-12}} = 10^6$$

Problem 11

https://www.eweek.com/

5.5 Billion smartphones by 2022

Problem 12

Per https://www.eweek.com/:
Android: 85%
iOS: 13%
Windows: 0.04%

Problem 13

Per https://www.statista.com/:
In 2019, 1.56 billion devices were sold and there are 5.11 billion users.

Roughly a third of users bought a new phones meaning the market life of a smartphone is short, 2-3 years.

Problem 14

Using the number of smart devices sold, obtained in the previous problem, we can calculate that approximately $\$75x10^9$ is invested annually into the salary of the engineers which support the smart phone industry:

$Investment = 1.56E9 * \$500 * 0.1 = 75E9$

By dividing the investment by the average engineer salary, we can calculate the approximate number of engineers supporting the industry to be approximately 1 million engineers:

$$N_{engineers} = \frac{75E9}{70E3} = \frac{75}{70}E6 = 1.071E6$$

Problem 15

The approximate die size of the Intel Skylake processor is $122.4mm^2$.

(a) Area of the wafer $= A_{wafer} = \pi\left(\frac{450mm}{2}\right)^2 = 159{,}043mm^2$

$N = \frac{A_{wafer}}{A_{die}} = 1299$

(b) Cost / Die $= \frac{\$2500}{1299*0.9} = \$2.13\ per\ chip$