Homework Set #1 Solution

Problem #1

a) Here we assume 100-nm-square pixels (100 nm per side)

$$A_{pix} = 100^2 \ nm^2 = 1e-14 \ m^2$$

$$A_{wafer} = \pi 300^2 / 4 \ mm^2 = 0.071 \, m^2$$

$$N_{pixels} = \frac{A_{wafer}}{A_{pix}} = 7e12$$

b) We know the bits per hour is $100 * N_{pixels} = 7e14 \frac{bits}{hr} \Rightarrow 2e11 \frac{bits}{\sec}$

Compare to LAN connection $K = \frac{2e12}{100e6} = 20000$ (much greater)

Compare to multiplexed optical fiber $K = \frac{2e12}{1e12} = 2$ (similar magnitude)

c) Cost in \$/(bit/sec) is calculated directly from what we found in part b when the tools costs \$25M

$$\frac{\$25e6}{2e11 \, bits/\sec} \approx 1e-4 \frac{\$}{bits/\sec}$$

d) The bit error rate is $10 / N_{pixels} = 1.4e-12$. This is similar to a fiber-optic communication channel

e) Similar to part a: $N_{pix/chip} = \frac{A_{chip}}{A_{pix}} = 9e10$

f) State of the art memory chip = 500 MB= 4e9 Bits

$$A_{pix} = \frac{A_{chip}}{N_{pix/chip}} = \frac{.0009 \, m^2}{4e9} = 2.25e-13 \, m^2 \quad \Rightarrow \quad L_{side} \approx 500 \, nm$$

g) Assume a 500 dpi black and white printer. The page is approximately 100 square inches. Assume that each page can be printed in 10 seconds. Then the information throughput is given by:

$$1000^2 \frac{bits}{in^2} \times \left(100 \, in^2\right) / \left(10 \sec onds\right) = 1e7 \frac{bits}{\sec}$$

h) From part g we get:

$$\frac{\$100}{1e7\ bits/\mathrm{sec}} \approx 1e-5 \frac{\$}{bits/\mathrm{sec}}$$

This is a factor of 10 cheaper than that found in part c.

Problem #2

In “There is plenty of room at the bottom,” Feynmann presents the potential for manipulation down to the atom by addressing the scaling of physics without much consideration of process constraints. He provides an overview and inspiration for scaling down devices and fabrication methods. Buck and Shoulders present a potential method in more detail for achieving a microminiature circuit. This is based on thin-film processing that has since then become the core of microtechnology.