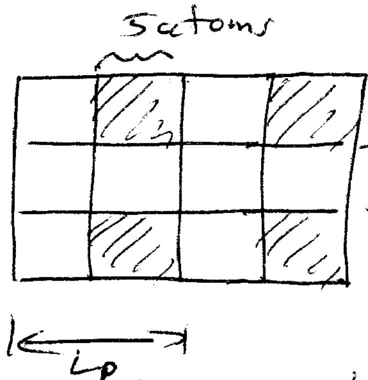
Hmk #2

1.)

Top View



▨ = Ge
□ = Si

→ similarly in vertical (z) direction

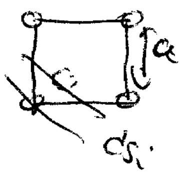
$L_p = L_{Si} + L_{Ge}$

= 5 × atomic spacing

$= 5 d_{Si} + 5 d_{Ge}$

$d_{Si} = \frac{\sqrt{3}}{4} a_{Si}$

a = cubic lattice constant
= 0.5431 nm Si
0.5658 nm Ge



$d_{Si} = 0.235$ nm

$d_{Ge} = \frac{\sqrt{3}}{4} \times 0.5658\text{ nm} = 0.245\text{ nm}$

so $L_{period} = 5 \times 0.235\text{ nm} + 5 \times 0.245\text{ nm}$
$= 2.4$ nm per bit that consists of Ge dot surrounded by Si

a) surface bit density:

$1\text{ bit}/(2.4\text{ nm})^2 = 1.736 \times 10^{13}\text{ cm}^{-2}$

$= 17.36$ Terabits/cm² $= \rho^{2D}$

b) volume density

$1\text{ bit}/(2.4\text{ nm})^3 = 7.23 \times 10^{19}\text{ cm}^{-3} = \rho^{3D}$

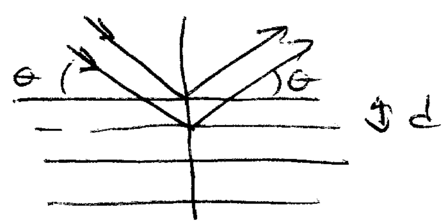
c) area for 1 Terabit; $\text{Bits} = \rho^{2D} \times A$

$A_{1T} = \frac{1\text{ Tbit}}{17.36\text{ Tbits/cm}^2} = \frac{1}{17.36}\text{ cm}^2 = 0.0576\text{ cm}^2$

d) Bits in 1 cm^2 × 10 layers.

$$\text{Bits} = 17.36 \text{ Tbits/cm}^2 \times 10 \text{ periods}$$
$$= 173.6 \text{ Tbit}$$

2.) Bragg diffraction $2 d \sin\theta = n\lambda$



$$\theta = \sin^{-1} \frac{n\lambda}{2d}$$

$$\lambda = \frac{2 d \sin\theta}{(n = \text{order})} = \frac{2 \times 2.4\,\text{nm} \overbrace{\sin 45^\circ}^{\sqrt{2}/2}}{n}$$

a) $\lambda = 3.394$ nm for 1st order ($n=1$) at 45°
for every bit active (1111... bit pattern)

b) if it were possible to turn every other bit off
(1010 --) then deffactive → 2d

$$\theta = \sin^{-1} \frac{3.394\,\text{nm}}{2 \times 2 \times 2.4\,\text{nm}} = \sin^{-1}[0.3535]$$
$$= 20.7^\circ$$

c) for $\lambda_{CuK\alpha} = 0.154$ nm $= 1.54$ Å

$$\theta = \sin^{-1}\left[\frac{0.154\,\text{nm}}{2 \times 2.4\,\text{nm}}\right] = \sin^{-1}(0.0321) = 1.84^\circ$$

d) it seems that x-rays could diffract from
the quantum dot bit pattern

3) assume that the 20 nm refers to L_G

$W = 5 L_G = 100\ nm$

$t_{ox} = 0.8\ nm = 8\ \mathring{A}$

a) $f_T = \frac{v_{sat}}{2\pi L_g} \rightarrow v_{sat} = 2\pi L_g f_T$

$= 1.5\ THz$

$v_{sat} = 2\pi \times 20\ nm \times 1.5\ THz$

$= 1.885 \times 10^{7}\ cm/sec$

b) this is realistic because ~~v_{sat}~~ for Si $v_{sat} \sim 1$ to $2 \times 10^{7}\ cm/sec$

c) how many e^- on gate with $V_{GS} - V_T = 1$ volt.

$C_{ox} = \frac{K_{ox} \epsilon}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-14}\ F/cm}{0.8 \times 10^{-7}\ cm}$

$= 4.3 \times 10^{-6}\ F/cm^2 = \frac{4.3 \times 10^{-6}\ F}{10^{8}\ \mu m^2 = 1\ cm^2}$

$= 43\ fF/\mu m^2$

d) $C = \frac{\Delta Q}{\Delta V}$ $\quad Q = qN = C\Delta V$

$N = \frac{43\ fF/\mu m^2 \times 1V \times (20\ nm \times 100\ nm)}{q = 1.6 \times 10^{-19}\ C}$

$N_{gate} = 539$ electrons