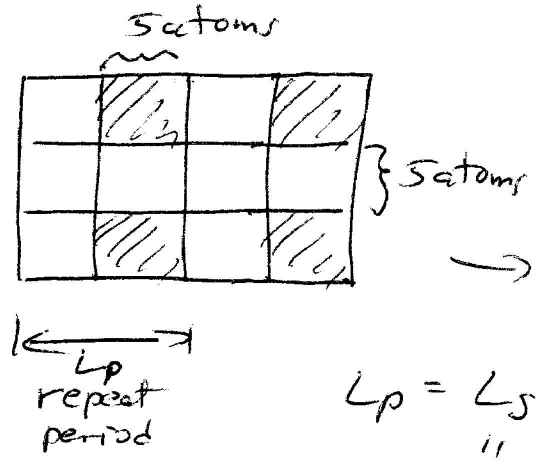
Hmk #2

1.)

Top View



▨ = Ge
□ = Si

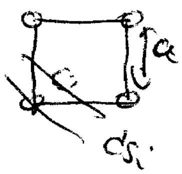
→ similarly in vertical (z) direction

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

= 5× atomic spacing

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

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

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

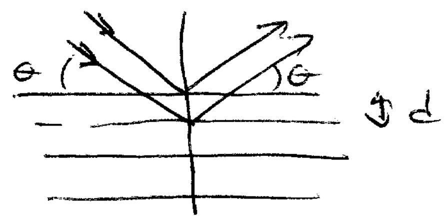
c) area for 1 Terabit; Bits $= \rho^{2D} \times A$

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

d) Bits in $1\,cm^2 \times 10$ layers.

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

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



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

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

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 deffective $\rightarrow 2d$

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

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

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

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

3) assume that the 20 nm refers to L_G

$W = 5 L_G = 100\ nm$

$t_{ox} = 0.8\ nm = 8\ \AA$

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

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

$N_{gate} = 539$ electrons