Now, $\frac{1}{V} \frac{d(N\varepsilon)}{dT} = C_V$

$\Rightarrow \underbrace{K}_{\text{Thermal conductivity}} = \cancel{\frac{1}{3}} \frac{1}{3} v^2 \tau C_V$ → If the electrons can absorb more heat ~~than~~ than its thermal conductivity will be more.

• Now, $\sigma = \frac{ne^2\tau}{m}$

Now, $\frac{K}{\sigma} = \frac{\frac{1}{3} C_V \cdot m v^2}{ne^2}$

Now, $\frac{1}{2} m v^2 = \frac{3}{2} K_B T$ → 100 times higher in reality.

} When considering electrons as ideal gas (Wrong but Drude considered it right)

Now total energy $\Rightarrow E = \frac{3}{2} n K_B T$

$\Rightarrow C_V = \left.\frac{dE}{dT}\right|_V = \frac{3}{2} n K_B$ → about 200 times ~~to~~ lower in reality

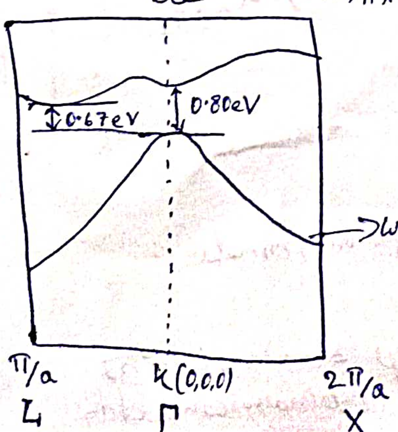
$\therefore \frac{K}{\sigma} = \frac{3}{2} \left(\frac{K_B}{e}\right)^2 T$

• Seebeck effect

25/08/2022

Band Gap Variation and lattice constant Variation of compound Semiconductors

Ge → At 300K

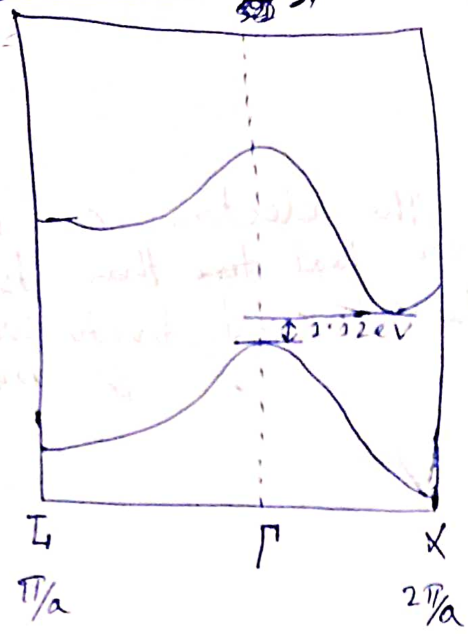


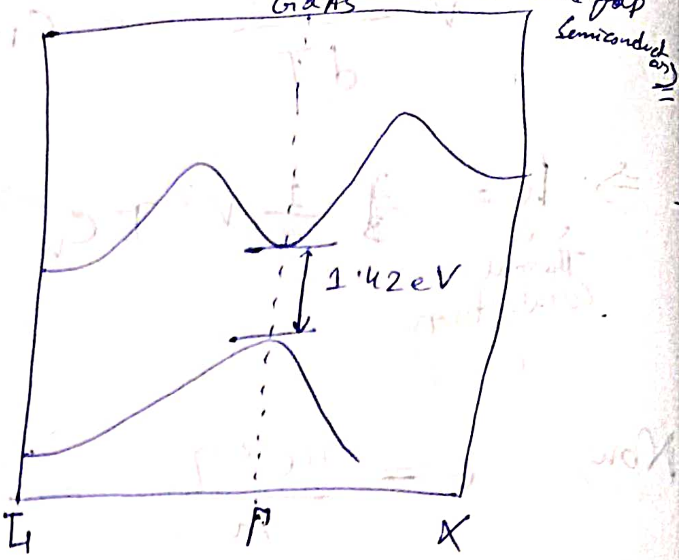
Thus Ge is an indirect bandgap semiconductors

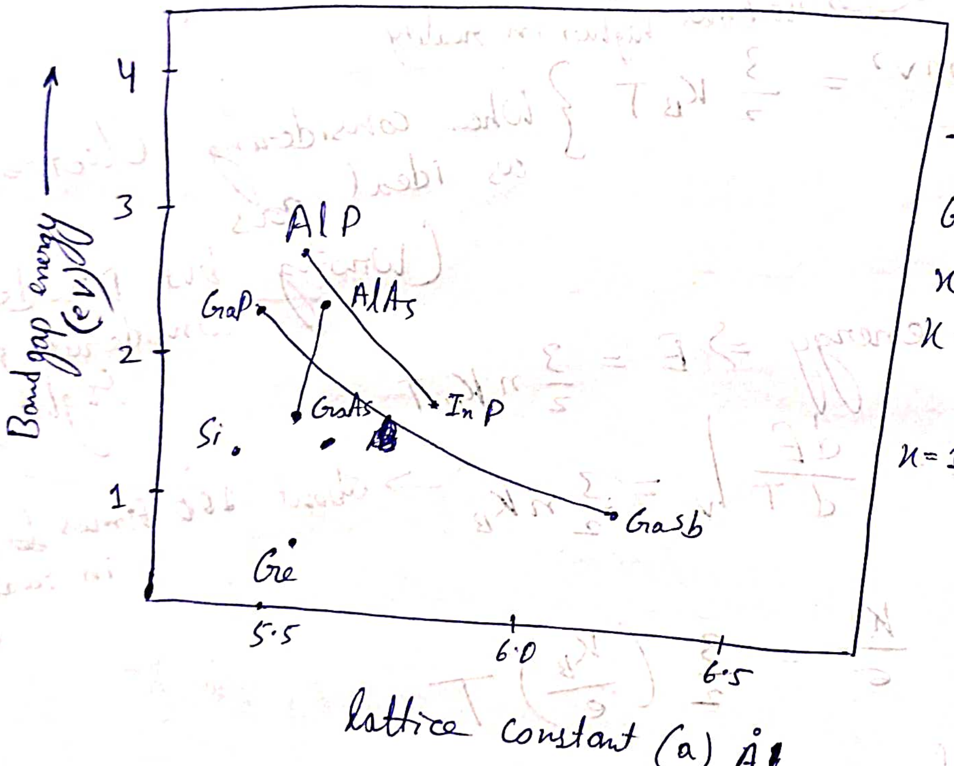
→ wave function for valance band with valance Band maxima at K=0

→ Gamma (Γ) band, L (L) band, X (X) band

Indirect Band Gap Semiconductor Si   at 300 K   ~~GaAs~~ GaAs (Direct band gap Semiconductor)







$Al_x Ga_{1-x} As$

$x \rightarrow$ mole fraction

GaAs $\rightarrow$ 1.43 eV

$x \rightarrow 0$ to 1

$x = 0 \rightarrow$ GaAs (1.43 eV)

$x = 1 \rightarrow$ AlAs (2.1 eV)

Vegard's law $\rightarrow$ To find the lattice constant

$$a_{Al_x Ga_{1-x} As} = x\, a_{AlAs} + (1-x)\, a_{GaAs}$$

Crystal approximation formula

Now,

$$E_g(x) = E_{g_0} + bx + cx^2$$ $\rightarrow$ linear approximation formula

$E_{g_0} \rightarrow$ bandgap of the lower bandgap ~~semiconductor~~ binary conduct b → fitting parameter

c → bowing parameter (should be < 1.0 and less than the parent semiconductor band gap)
→ Go down

According to the crystal approximation formula →

$$E_g(x) = x E_g^A + (1-x) E_g^B$$

[Where, E_g^A → GaAs
E_g^B → AlAs]

Now

For $Al_x Ga_{1-x} As$

only valid for

$$E_g^{\Gamma}(x) = 1.425 + 1.247x$$

→ Γ (Direct band gap) (i.e. $x \leq 0.45$ for this material)

*** From experimental data
(Remember AlGaAs, InGaAs, etc)

$$= 1.425 + 1.247x + 1.147(x - 0.45)^2$$

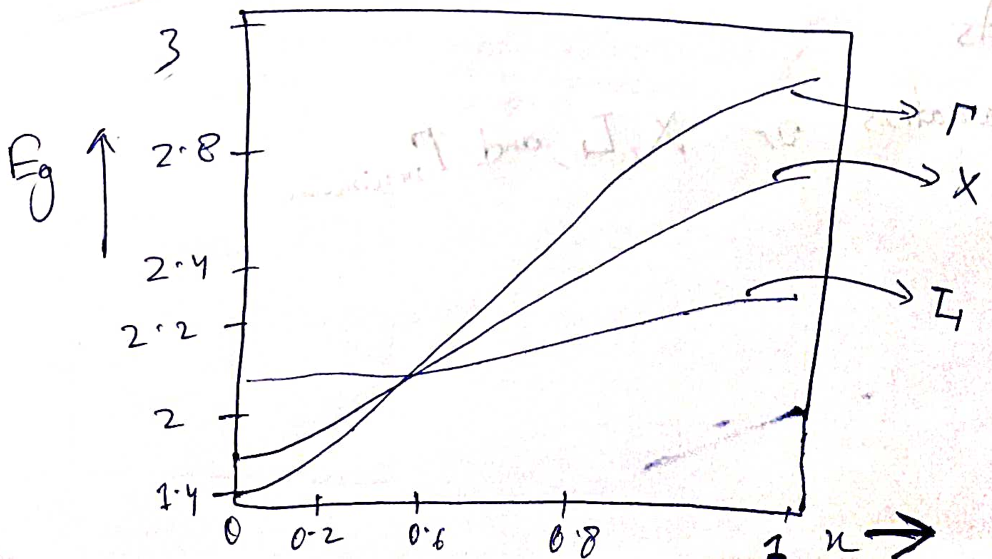
(Indirect at ($x > 0.45$))

Now

$$E_g^X(x) = 1.9 + 0.125x + 0.143x^2$$

$$E_g^L(x) = \cancel{1.4} \; 1.708 + 0.642x$$

Now, ~~BZD~~ Drawing a graph with these equations



I) • $Al_x In_{1-x} P$

Calculate the lattice constant for $x = 0.53$

Ans) $a_{Al_x In_{1-x} P} = \cancel{x\, a_{InP} + (1-x) a_{AlP}}$

$x\, a_{AlP} + (1-x)\, a_{InP}$

Now to find the band gap

$Al_x In_{1-x} P = 1.351 + 2.23x$

Note

$$eV = \frac{1.24}{\lambda (\mu m)}$$

To get a particular emission by changing the bandgap.

only valid for Γ (For L and X we have different equations)

• $Al_x In_{1-x} As = 0.36 + 2.012x + 0.698x^2$

Q) $In_{0.53} Ga_{0.47} As$

Find out lattice constant and the band Gap only for Γ.

Q) For $InAs_{0.4} P_{0.6}$

Q) $Al_{0.35} Ga_{0.65} As$

Calculate the variations of X, L, and Γ minimum