Mo Tu We Th Fr Sa Su Date:

GaAs $Al_x Ga_{1-x} As$

$$E_g^{\Gamma}(x) = 1.425 + 1.155x + 0.37x^2 \Rightarrow \text{sharpest}$$

$$E_g^{X}(x) = 1.911 + 0.005x + 0.37x^2$$

$$E_g^{L}(x) = 1.734 + 0.574x + 0.055x^2$$

Γ-X crossover occurs in the compositional range of $0.4 \leq x \leq 0.5$

This energy gap is also T dependent. An empirical equation is given by

$$E_i(T) = \frac{E_{i0} - \alpha T^2}{(T+\beta)}$$

where $E_{i0} = 1.519$ eV
$\alpha = 5.405 \times 10^{-4}$ eV/K
$\beta = 204$ K
for $0 < T < 1000$ K

It has a quadratic dependence on temp. for small T, changing towards a linear dependence for $T \gg \beta$.

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Effective mass at 0K

$m_{e0} = 0.067\, m_0$

heavy hole

$m_{h0} = 0.51\, m_0$

light hole

$m_l = 0.082\, m_0$

Hole mobility

Since effective mass is more than that of free electrons, mobility is lower.

$$\langle v_p \rangle (rms) = 1.77 \times 10^7 \left(\frac{T}{300}\right)^{1/2} cm\, s^{-1}$$

whereas

$$\langle v_e \rangle (rms) = 4.4 \times 10^7 \left(\frac{T}{300}\right)^{1/2} cm\, s^{-1}$$

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The curvature $\frac{d^2E}{dk^2}$ is +ve at the conduction band minima, but is -ve at the valence band maxima. Thus the electrons near the top of the valence band have -ve effective mass, according to

$$m^* = \frac{\hbar^2}{d^2E/dk^2}.$$

Valence band electrons with -ve charge and -ve mass move in an electric field in the same direction as holes with +ve charge and +ve mass.

Hydrogen like atom model
a loosely bound fifth electron as ranging about the tighty bound core electrons constitutes a hydrogen like orbit.

Hence for $n = 1$

$$E = \frac{m_n^* q^4}{2K^2\hbar^2}$$

where $K = 4\pi\epsilon_0\epsilon_r$

$$\hbar = \frac{h}{2\pi}$$

$$\Rightarrow E = \frac{m_n^* q^4}{8(\epsilon_0 \epsilon_r)^2 h^2}$$

$m_n^* = 0.067 \times m_0 = 0.067 \times 9.11 \times 10^{-31}$ kg

$q = 1.6 \times 10^{-19}$ J

$\epsilon_0 = 8.85 \times 10^{-12}$

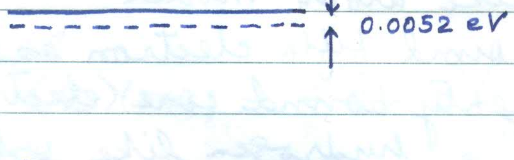
$\epsilon_r = 13.2$ for Si

$h = 6.63 \times 10^{-34}$ J-s

$\Rightarrow E = 8.34 \times 10^{-22}$ J

divide it by q, That gives energy in eV

$\Rightarrow E = 0.0052$ eV



Mo Tu We Th Fr Sa Su Date:

How to produce an extrinsic GaAs

i) Column VI impurities occupying column V sites serve as donors
S, Se, Te

ii) Column II impurities replacing column III elements serve as acceptors
Be, Zn, Cd

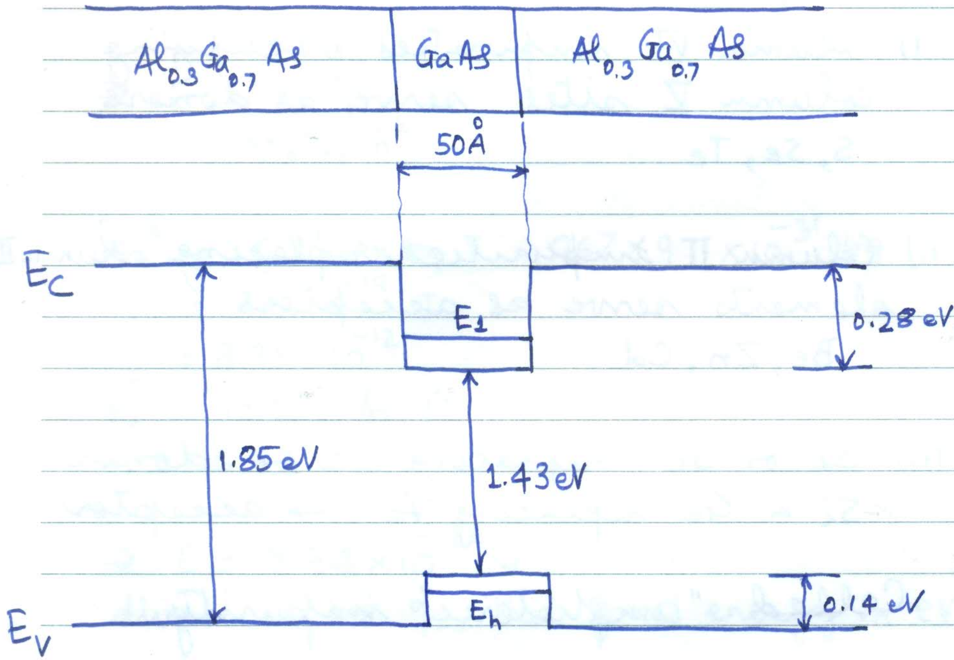
iii) Si or Ge replacing Ga → donor
Si or Ge replacing As → acceptor

Called "amphoteric" impurity

If we dope Si with 10^{15} As atoms/cm^3, the conduction electron concentration changes from 10^{10} cm^{-3} to 10^{15} cm^{-3} ⇒ 5 orders of magnitude

The resistivity of Si changes from about 2×10^5 Ω-cm to 5 Ω-cm with this doping.

Heterostructure & Quantum Well



Confining electrons and holes in a very thin layer results into a situation of particle in a potential well. Hence instead of a continuum of energy states in CB, now a free electrons sees discrete energy levels in CB and a hole sees similar in the VB.

Hence now one gets a photon of

$E_g + E_1 + E_h$ energy, higher freq. from IR to Red portion of spectrum.