DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB103J –Semiconduuctor Physics

1. Calculate the conductivity of intrinsic germanium at 300K using the following data.

Given data

$n_i = 2.4\times10^{19}\ \mathrm{m}^{-3}$; $\mu_e = 0.39\ \mathrm{m}^2 V^{-1}s^{-1}$; $\mu_h = 0.19\ \mathrm{m}^2 V^{-1}s^{-1}$

Solution:

$$\sigma_i = n_i e(\mu_e + \mu_h) = 2.4\times10^{19}\times1.6\times10^{-19}(0.39+0.19)$$ = 2.2272 (ohm metre)$^{-1}$

2. At what temperature we can expect a 10% probability that electrons in silver have an energy which is 1% above the Fermi energy? The Fermi energy of silver is 5.5eV.

Given Data

F(E) = 10% = 0.1

E_F = 5.5eV

E = E_F + = (5.5 + 0.055) = 5.555 eV

Hence E – E_F = 0.055 eV = $0.055\times1.6\times10^{-19}$ J

Solution:-

We know the probability function is given by

$$F(E)=\frac{1}{1+\exp(E-E_F/kT)},or,$$

$$0.1=\frac{1}{1+\exp\left(\frac{0.055\times1.6\times10^{-19}}{1.38\times10^{-23}\times T}\right)}$$

$$=\frac{1}{\exp\left(\frac{637.7}{T}\right)+1}$$

$$Hence,T=\frac{637.7}{\ln 9}=\frac{637.7}{2.197}$$

= 6.625

×

= 4.135eV

3. A cadmium sulphide *(Eg* = 2.4eV) photodetector is illuminated with light of wavelength 3000Å. The intensity of radiation falling on the detector is 30 W/m^2. The area of the detector is 9 mm^2. Assuming that each quantum generates an electron-hole pair, calculate the number of pairs generated per second.

Given data

wavelength= 3000 Å

Solution:-

$$E = \frac{hc}{\lambda} = \frac{6.625\times10^{-34}\times3\times10^{2}}{3000\times10^{-10}} = \frac{6.625\times10^{-19}}{1.602\times10^{-19}}eV = 4.13eV$$

Since this energy is higher than E_g(=2.4eV) electron-hole pairs will be generated.

Number of photons falling

$$= \frac{30 \times 9 \times 10^{-6}}{6.625 \times 10^{-19}} = 4.075 \times 10^{14}$$

Since each photon produces an electron-hole pair, the number of pairs generated per sec = 4.075×10^{14}

$F(E) = 0.269$

Exercise Problems

1. Evaluate the Fermi function for an energy kT above the Fermi energy

2.Calculate the number of states lying in an energy interval of 0.02eV above the Fermi energy for sodium crystal of unit volume (E_F = 3.22eV for sodium). (2.45×10^{26})


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