ESO 205T

Nature and Properties of Materials

Interaction session: 11-12 Monday
Tutorial: 11-12 Thursday

Assignment 9

Due by 26 October 2020 11 am

Question 1

Comment on the effect of increase in temperature on the electrical/ionic conductivity of the following materials with reasoning

1. Oxygen free high conductivity copper in annealed state
2. Oxygen free high conductivity copper in 90% cold rolled state
3. Germanium
4. GaAs
5. Sodium beta alumina (Na^+ doped beta Al_2O_3)

Question 2

The electrical conductivity and the electron mobility of aluminum are $3.8 \times 10^{7} (\Omega.m)^{-1}$ and $0.0012\ m^{2} \cdot V^{-1} s^{-1}$ respectively at room temperature.

(a) Compute the number of free electrons per cubic meter for aluminum at room temperature.

(b) What is the number of free electrons per aluminum atom? Assume a density of 2.7 g/cm^{3} and atomic weight of 26.98 g/mol.

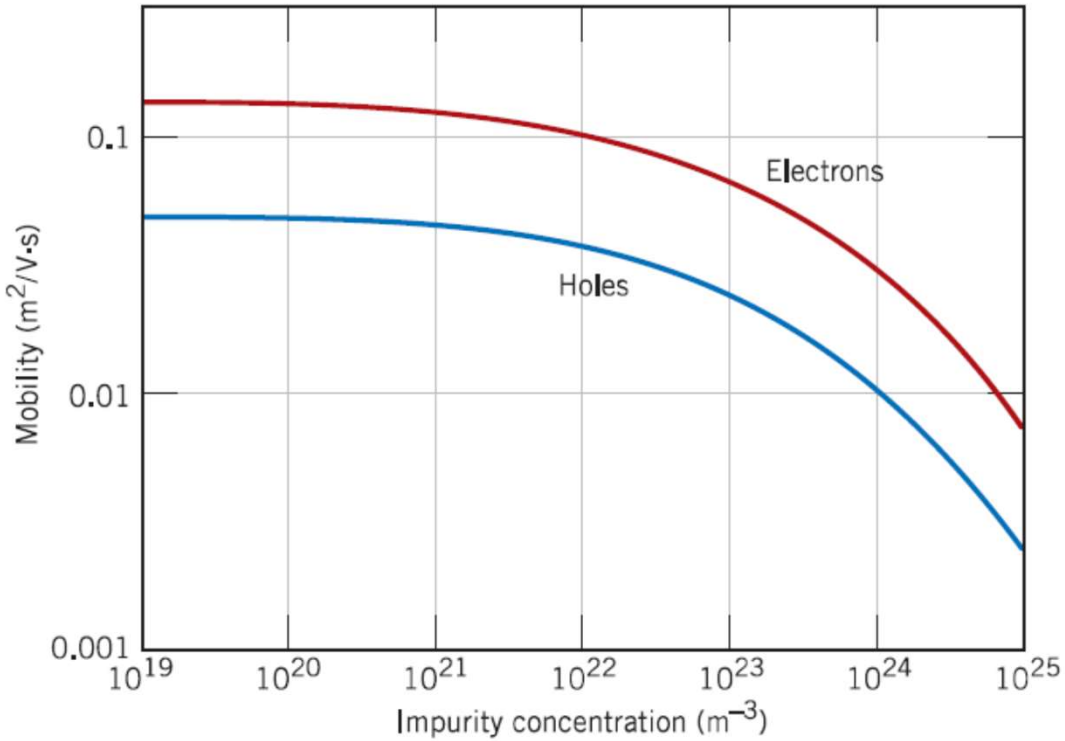
Question 3

The process of diffusion is employed to dope pure silicon with 10^{22} m^{-3} boron atoms. Determine

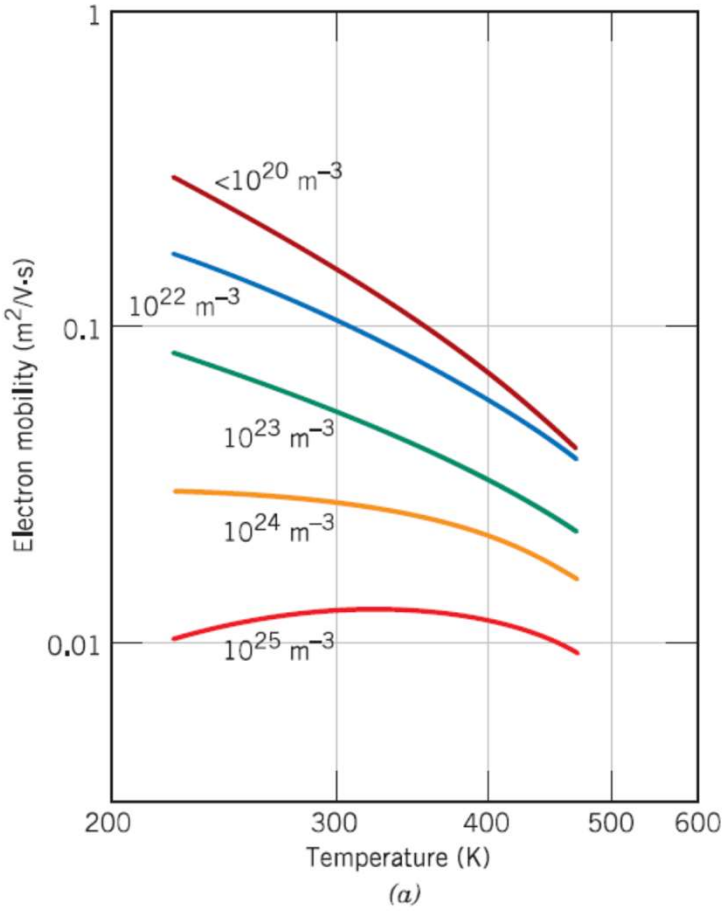
1. whether the material is p-type or n-type semiconductor
2. room temperature electrical conductivity of the material
3. electrical conductivity of the material at 150 ˚C

Please refer to diagrams on the next two slides

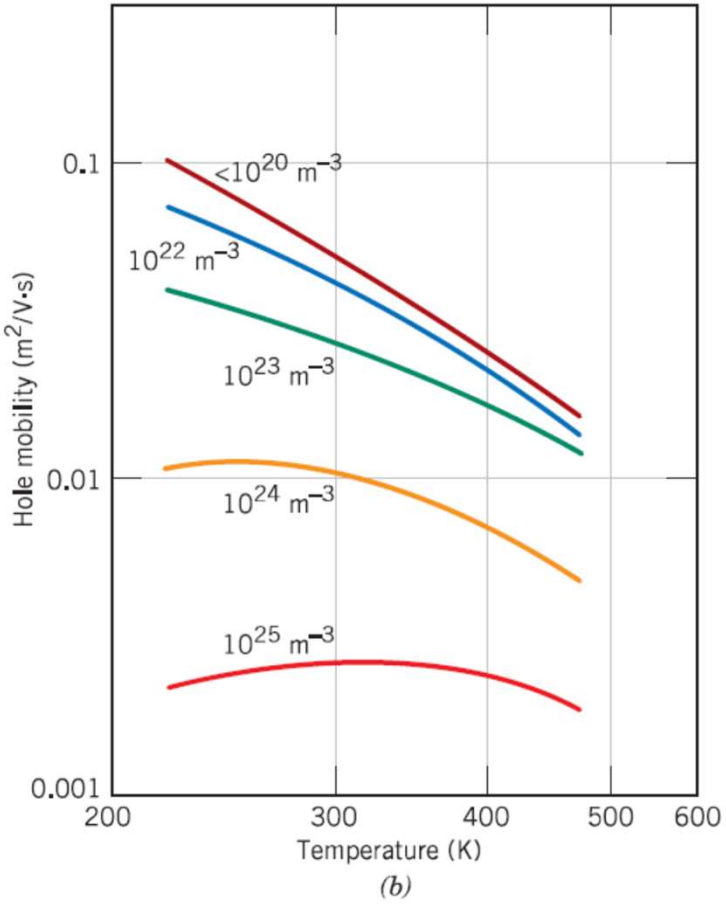
Impurity concentration and carrier mobility at room temperature



Electrons



Holes



Question 4

A process engineer in a semiconductor industry has manufactured a series of semiconductors transparent tolight in the visible spectrum. Determine the range of band gap energy for semiconductors synthesized by the process engineer.

Question 5

Consider a parallel-plate capacitor in the form of a square of 25 mm side and a plate separation of 2.5 mm across which a potential of 5 V is applied. If mica sheet with a dielectric constant of 5.0 is positioned within the region between the plates, determine

(a) the capacitance.

(b) the magnitude of the charge stored on each plate.

(c) the dielectric displacement D.

(d) the polarization.

Question 6

Where is the Fermi enrgy (E_F) located in the energy band of silicon, at 300K with

(a) number of electrons in CB (n) = 10^{24} m^{-3} ? and for

(b) number of holes in VB (p) = 10^{19} m^{-3} ?

(c) plot the Band Diagram in both cases.

Given: kT= 0.026 eV at room temperature, N_C =2.8 x 10^{25} m^{-3} and N_V = 1.5 x 10^{25} m^{-3}

Remember that the Fermi energy level lies between the valence abd the conduction band and the difference between the energy is given by kTln(Nc/n) or kTln(Nv/p)

Question 7

We were introduced to tensors and studied crystal structure in the class. Please comment on the rank of the following physical properties and the minimum number of independent components required to describe the property completely for materials with cubic symmetry

1. Dielectric constant
2. Piezoelectric co-efficient
3. Permeability