1

A new semiconductor was developed by fusing two elemental semiconductors using an atomistic simulation. The band structure and density of states were computed for room temperature and presented in Fig. A.

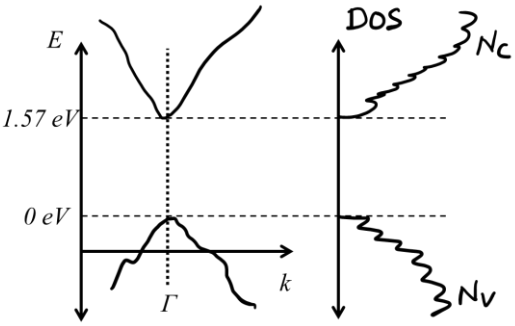

Fig. A. band structure and density of states of a new semiconductor

the effective mass of electron in conduction band was estimated as 1.055 from the rate of change of energy with momentum. The effective density of states at conduction and valance bands were found 1.24×10^{19} cm^{-3} and 1.84×10^{19} cm^{-3} respectively. Calculate:

1. Density of states 125 meV above and below the conduction band edge per 1 eV in a volume of 10 nm × 100 nm × 10 nm.
2. Bandgap of the semiconductor
3. Intrinsic carrier concentration

2

a. From an experiment on metal alloy, the drift velocity for the applied field is calculated as shown in Fig. B. It was found that the rate of change of drift velocity is 141.7 cm^2/V.s. If the density of the free electron $n = 9\times10^{21}\ m^{-3}$, find the electrical conductivity, mean free time between scattering and drift mobility. [5]

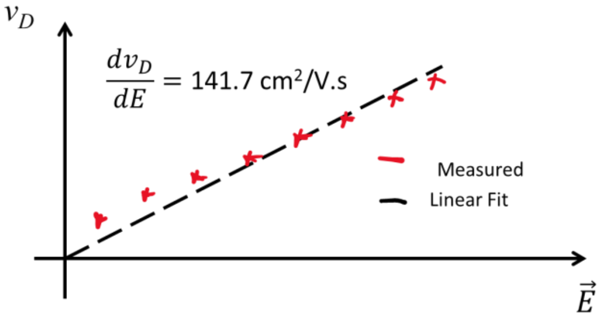

Fig. B. Drift velocity for the applied field

b. After doping 1% Si in a pure aluminum foil of width 1 cm and cross section area of 0.1 cm^2, the Hall experiment was conducted and found the following as listed in table-1, for the foil current of 70 A:

Table-1	
Hall Voltage (V_H)	Applied magnetic flux (B_0)
8 μV	3 T

Calculate the (a) Density of conduction electron, (b) Hall mobility, and (c) Hall coefficient. [5]

3	A new semiconductor has $N_C = 10^{19}$ cm^{-3}, $N_V = 5 \times 10^{18}$ cm^{-3}, and $E_g = 2.3$ eV. If it is doped with 10^{17} cm^{-3} donors (fully ionized), calculate: 1. Intrinsic carrier concentrations 2. Carrier concentration of Majority and Minority carriers 3. Position of E_F with respect to E_C. 4. Also calculate the Sketch the simplified band diagram, showing the position of E_F.
4	a. For a Si thin film of length 5 μm, doped n-type at 10^{15} cm^{-3}, calculate the current density for an applied voltage of 2.5 V across its length. The electron and hole mobilities are 1500 cm^2/V-s and 500 cm^2/V-s, respectively. b. After doping further to reach ND=10^{15} cm^{-3}, which reduced the mobility to half, calculate the drift velocity and current density for the same applied potential.
5	An Si sample has n-doped with $N_D = 6\times10^{14}$ cm^{-3} donors and p-doped with $N_A = 5\times10^{13}$ cm^{-3} acceptors. Calculate the conductivity of the sample and the position of the fermi level relative to the conduction band edge. (Assume, $N_C = 2.8 \times 10^{19}$cm^{-3}, $N_V = 1\times10^{19}$ cm^{-3}) $\mu_n = 92 + \frac{1268}{1+\left\{\frac{Na+Nd}{1.3\times10^{17}}\right\}^{0.91}}$ cm^{2}V^{-1}s^{-1} , and $\mu_p = 47.7 + \frac{447.3}{1+\left\{\frac{Na+Nd}{6.3\times10^{16}}\right\}^{0.76}}$ cm^{2}V^{-1}s^{-1}
6	A Si sample is doped with 6×10^{15} cm^{-3} donors and 2×10^{15} cm^{-3} acceptors. Find the position of Fermi level with respect to E_C at 300 K. Draw the band diagram neatly.
7	A particular type of n-type Germanium has a resistivity of 0.1 Ohm m at 300 K, calculate the donor concentration. Assume $\mu_n = 0.38$ m^2/V.s
8	A Si sample with 10^{16}/cm^3 donors is optically excited such that 10^{19}/cm^3 electron-hole pairs are generated per second uniformly in the sample. The laser causes the sample to heat up to 450 K. Find the change in conductivity of the sample upon shining the light. Electron and hole lifetimes are both 10 μs. $D_p = 12$ cm^2/s, $D_n = 36$ cm^2/s, $n_i = 10^{14}$ cm^{-3} at 450 K.
9	A 10 cm long n-type Si thin film has donor impurity concentration 3×10^{18} cm^{-3}, for which the drift mobility of the sample was found 854 *cm^2/V·s*. Compute the drift current for the applied potential of 10 V across the sample, if the sample cross section of 0.1 cm^2. On the UV light illumination, the excess carriers of 2×10^{16} cm^{-3} were generated which recombine with a rate of 10^{22}/s·cm^3. Compute the minority carrier life time, current after illumination of light.