NITC/EC/LR/GS/SD/12/02/2025

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NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Department Of Electronics and Communication Engineering
II Semester B. Tech Mid Semester Examination
Winter Semester 2024- 2025

Semiconductor Devices (Code: EC1012E)

Time: 120 Minutes | Maximum Marks: 20

(i) Answer all the questions.
(ii) Draw neat sketches wherever necessary.
(iii) Assume any missing data with proper justification

{Boltzmann constant $k = 1.38\times10^{-23}$ J/K, Electronic Charge $q = 1.6\times10^{-19}$ C, Electron rest mass $m_o = 9.1\times10^{-31}$Kg, Planck's constant $h = 6.63\times10^{-34}$ J-s, E_G for Si = 1.11 eV, $n_i = 1.5 \times 10^{10}$ /cc for Si at 300K, ε_r for Si is 11.2}

1. **a.** At 300 K the lattice constant for silicon is 5.43 Å. Calculate the number of silicon atoms per cubic centimeter and the density of silicon at room temperature having diamond structure (8 atoms per unit cell). Atomic weight of silicon is 28.09g/mol. **(1)**

   b. The lattice constant of a simple cubic lattice is a_0. Sketch the following planes: **(i)** (110), **(ii)** (111), **(iii)** (220), and **(iv)** (321). **(1)**

2. **a.** Two possible conduction bands and two possible valence bands are shown in the E versus k diagram given in Figure 1 and Figure 2. State which band will result in the heavier electron and hole effective mass; state why **(1)**

fig.1

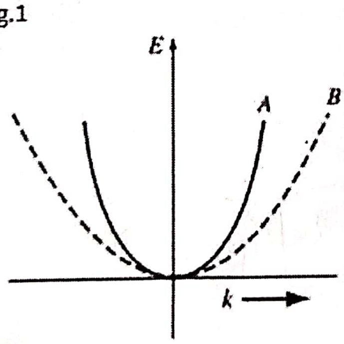
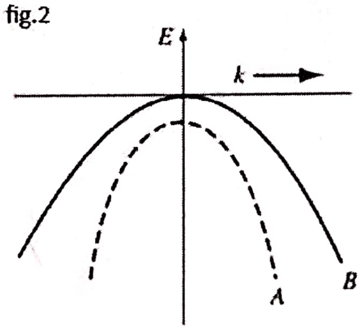


fig.2



   b. Draw the graph for electron density as a function of temperature for Silicon sample. Take temperature range from 0 K to 600 K. Mark and briefly explain different regions in the graph. **(1)**

3. At room temperature (300 K) the effective density of states in valence band is 2.66×10^{19} cm^{-3} for Silicon and 7×10^{18} cm^{-3} for GaAs. Find the corresponding effective masses of holes. Compare these masses with free electron mass **(2)**

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4. A silicon sample is doped with 5×10^{16} As atoms /cm^3 and 2×10^{16} B atoms /cm^3. Determine Electron and hole concentrations at room temperature and the position of Fermi level. (2)

5. a. Assume that, in an n type semiconductor at T=300K, the electron concentration varies linearly from 1×10^{18} to 7×10^{17} cm^{-3} over a distance of 0.1 cm. Calculate the diffusion current density if the electron diffusion coefficient is D_n=22.5 cm^2/s (1)

   b. Minority carriers (holes) are injected into a homogeneous n-type semiconductor sample at one point. An electric field of 50 V/cm is applied across the sample, and the field moves these minority carriers at a distance of 1 cm in 100μs. Find the drift velocity and diffusivity of minority carriers. The temperature is 300 K. (1)

6. The Fermi level position in a silicon sample at 300 K is 0.29 eV below E_c. Determine the carrier concentrations and conductivity of the specimen. Given that n_i = 1.5x 10^{10} cm^{-3}, μ_n = 1350 cm^2/Vs, μ_p = 480 cm^2/Vs. (2)

7. Determine the probability that an energy level 3kT above the Fermi energy is occupied by an electron. Assume T = 300K (2)

8. Calculate the intrinsic carrier concentration in gallium arsenide (GaAs) at room temperature (T=300K). Energy gap, Eg, of GaAs is 1.42 eV. The value of Nc and Nv at 300 K are 4.7 x 10^{17} cm^{-3} and 7.0 x 10^{18} cm^{-3}, respectively. (2)

9. Consider a metal at absolute zero temperature. The metal has a density of states given by $D(E)=3E^2$, and the Fermi energy E_F is 5 eV. Calculate the total number of electrons per unit volume (n) in the metal at absolute zero. Lowest energy level is 0 eV. (2)

10. A silicon sample has a cross-sectional area of 0.5 cm² and a length of 1 cm. It is doped with phosphorus atoms to a concentration of 10^{16} cm^{-3}. The electron mobility in silicon is 1350 cm²/V·s, and the hole mobility is 480 cm²/V·s. A voltage of 5V is applied across the sample. Find: Electrical conductivity (σ) of the sample, Electron and hole drift velocities in the sample, and Drift current (I_d) through the sample. (2)

---**All the best**---