Benha University
Faculty of Engineering at Shoubra
Electrical Engineering Department

Solid State Electronic Devices
3rd Term – Level 1 / Credit H
Sheet 01 - (Fall 2017)

OPTOELECTRONICS

SHEET 1

1. Calculate the effective density of states for electrons and holes in germanium, silicon and gallium arsenide. Use the effective masses provided in the table below. Calculate the intrinsic carrier density in germanium, silicon and gallium arsenide at room temperature (300 K). Repeat at 100 ° C. Assume that the energy bandgap is independent of temperature and given by the values provided below.

Name	Symbol	Germanium	Silicon	Gallium Arsenide
Energy bandgap at 300 K	E_g (eV)	0.66	1.12	1.424
Effective mass for density of states calculations				
Electrons	m_e/m_0	0.56	1.08	0.067
Holes	m_h/m_0	0.29	0.81	0.47
Effective density of states in the conduction band at 300 K	N_C (cm^{-3})			
Effective density of states in the valence band at 300 K	N_V (cm^{-3})			
Intrinsic carrier density at 300 K	n_i (cm^{-3})			
Effective density of states in the conduction band at 100 ° C (373.15 K)	N_C (cm^{-3})			
Effective density of states in the valence band at 100 ° C	N_V (cm^{-3})			
Intrinsic carrier density at 100 ° C	n_i (cm^{-3})			

2- Calculate the position of the intrinsic energy level (intrinsic Fermi level E_{Fi}) relative to the midgap energy $(E_c + E_v)/2$ in germanium, silicon and gallium arsenide at 300 K. Repeat at T = 100 °C. Use the table and results of problem 1.

Name	Units	Germanium	Silicon	Gallium Arsenide
Solution at 300 K	meV	12.8		
Solution at 100 °C	meV			

3- Calculate the electron and hole density in germanium, silicon and gallium arsenide if the Fermi energy is 0.3 eV above the intrinsic Fermi energy level. Repeat for a Fermi energy which is 0.3 eV below the conduction band edge. Assume that T = 300 K.

Name	Units	Germanium	Silicon	Gallium Arsenide
	cm^{-3}			
	cm^{-3}			
	cm^{-3}			
	cm^{-3}			

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4 - A silicon wafer contains 10^{16} cm^{-3} electrons. Calculate the hole density and the position of the intrinsic Fermi energy and the Fermi energy at 300 K. Draw the corresponding band diagram to scale, indicating the conduction and valence band edge, the intrinsic Fermi energy level and the Fermi energy level.

(**Use $n_i = 10^{10}$ cm^{-3}**)