Unit 6 - Week 5: Metal-Semiconductor Junctions

Assignment 5

The due date for submitting this assignment has passed. As per our records you have not submitted this assignment. Due on 2018-09-12, 23:59 IST.

1) Assume an arbitrary metal forms a Schottky contact with an n-type semiconductor. How does the Schottky barrier height vary if the doping in the semiconductor decreases?

- increases
- decreases
- remains unchanged
- becomes zero

No, the answer is incorrect.
Score: 0
Accepted Answers: remains unchanged

2) An arbitrary metal is deposited on a lightly doped n-type semiconductor. Work-function of the metal is much higher than the work-function of the semiconductor. Which of the following steps will make the metal-semiconductor contact an ohmic one?

Assume an ideal contact with no surface states.

- Doping the semiconductor heavily (degenerate doping) with an n-type impurity near the contact region.
- Doping the semiconductor heavily with a p-type impurity far away from the contact.
- Doping the semiconductor lightly with a p-type impurity near the contact to make the semiconductor an intrinsic one.
- No further processing is required, as it is already an ohmic contact.

No, the answer is incorrect.
Score: 0
Accepted Answers: Doping the semiconductor heavily (degenerate doping) with an n-type impurity near the contact region.
Consider a (chromium) - (n-type silicon) metal-semiconductor junction. The semiconductor is doped with \( N_D = 10^{17} \, \text{cm}^{-3} \). Calculate the Shottky barrier height (in eV) and the built-in potential (in V) at \( T = 300 \, \text{K} \).

Use the following parameters, if required:
- Work-function of chromium = 4.5 eV
- Electron affinity of silicon = 4.05 eV
- Band gap of silicon = 1.12 eV
- \( N_C = 2.82 \times 10^{19} / \text{cc} \), \( N_V = 1.83 \times 10^{19} / \text{cc} \) (for silicon)
- Dielectric constant of silicon = 11.9.

No, the answer is incorrect.
Score: 0

Accepted Answers:
- \( 0.45, \ 0.3 \)

5) Consider the metal-semiconductor junction given in the previous question (question no. 4). Instead of n-type doping, now consider the p-type doped Si with the dopant concentration, \( N_A = 10^{17} \, \text{cm}^{-3} \). What will be the Schottky barrier height (in eV) and the built-in potential (in V)?

No, the answer is incorrect.
Score: 0

Accepted Answers:
- \( 0.67, \ 0.53 \)

6) Consider the (chromium) - (n-type Si) MS junction given in the question number 4. Calculate the following quantities when the junction is reverse biased with 5 V:
   i) the depletion layer width (in \( \mu \text{m} \))
   ii) the electric field at the metal semiconductor interface (in \( V/\text{cm} \))

No, the answer is incorrect.
Score: 0

Accepted Answers:
- \( 0.67, \ 0.53 \)
7) Consider the (chromium) - (n-Si) MS junction given in question 4. The junction is subjected to a 5 V reverse bias. Calculate i) the potential drop across the semiconductor (in V) and the junction capacitance per unit area (in nF/cm²).

- i) 0.02
- ii) 1e4

No, the answer is incorrect.
Score: 0
Accepted Answers:
- i) 0.26
- ii) 3.95e5

8) The capacitance, $C$ of a Schottky diode is given by the relation $\frac{1}{C} = a - bV$, with $V$ the applied voltage. $a$ and $b$ are constant coefficients. Calculate i) the built-in potential ($\phi_{bi}$) and ii) the donor concentration ($N_D$).
Assume, the permittivity of semiconductor $= \epsilon_s$ and the junction cross-section area $= A$.

- i) $\phi_{bi} = \frac{\epsilon_s q N_D}{2b}$
- ii) $N_D = \frac{2}{\epsilon_s q N_D a}$

- i) $\phi_{bi} = \frac{\epsilon_s A^2 q N_D a}{2}$
- ii) $N_D = \frac{2}{\epsilon_s A^2 q b}$

- i) $\phi_{bi} = \frac{2}{\epsilon_s q N_D a}$
- ii) $N_D = \frac{q A^2}{\epsilon_s q b}$

- i) $\phi_{bi} = \frac{2N_D}{\epsilon_s q N_D a}$
- ii) $N_D = \frac{\epsilon_s A^2}{q N_D a b}$

No, the answer is incorrect.
Score: 0
Accepted Answers:
- i) $\phi_{bi} = \frac{\epsilon_s A^2 q N_D a}{2}$
- ii) $N_D = \frac{2}{\epsilon_s A^2 q b}$

9) A metal semiconductor contact is made with Au (work function $= 5.1 \text{ eV}$) and n doped Si $^1$point with $N_D = 1e15$/cc. If the metal contact is kept 5 V below the semiconductor, what is the electric field in the semiconductor at the distance of 1 $\mu$m from the junction at $T = 300 K$?
Assume, $N_C = 2.82e19$/cc, electron affinity of Si $= 4.05 \text{ eV}$ and the relative permittivity of Si $= 11.8$

- $-1.52 \text{ kV/cm}$
10. Which of the following is not correct regarding an M-S junction? 

- Thermionic emission depends on the shape of the band bending inside the semiconductor near the junction.
- Tunneling current through a triangular barrier at the junction increases with the doping concentration in the semiconductor.
- Diffusion transport through a junction is negligible in case of reverse bias.
- Thermionic emission transport enhances with the increase in temperature.

No, the answer is incorrect.
Score: 0
Accepted Answers:

Thermionic emission depends on the shape of the band bending inside the semiconductor near the junction.