EEE112 REVIEW SESSION

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May 16th 2024

Final Exam Structure

Duration: **2 hours**
Type: Closed Book Exam

Final Exam = **Section A** + **Section B**

Section A (40%): 20 MCQs (2% each)
For each question, **select just ONE of the four possible answers**, and **write its letter (a), (b), (c) or (d) on the answer booklet(s)**.

Section B (60%): 3 questions
Answer should be written on the **same answer booklet(s)** provided and submitted after the exam.

Section A (40%)

Example 1

CT2. Which one is correct?

(A)

- E_v is bottom edge of the conduction band
- E_c is top edge of the valence band
- E_c and E_v are separated by the **band gap energy** E_g

(B)

- E_c is bottom edge of the conduction **level**
- E_v is top edge of the valence **level**
- E_c and E_v are separated by the **level** gap energy E_g

(C)

- E_c is bottom edge of the conduction **band**
- E_v is top edge of the valence **band**
- E_c and E_v are separated by the **band** gap energy E_g

Section A (40%)

Example 2

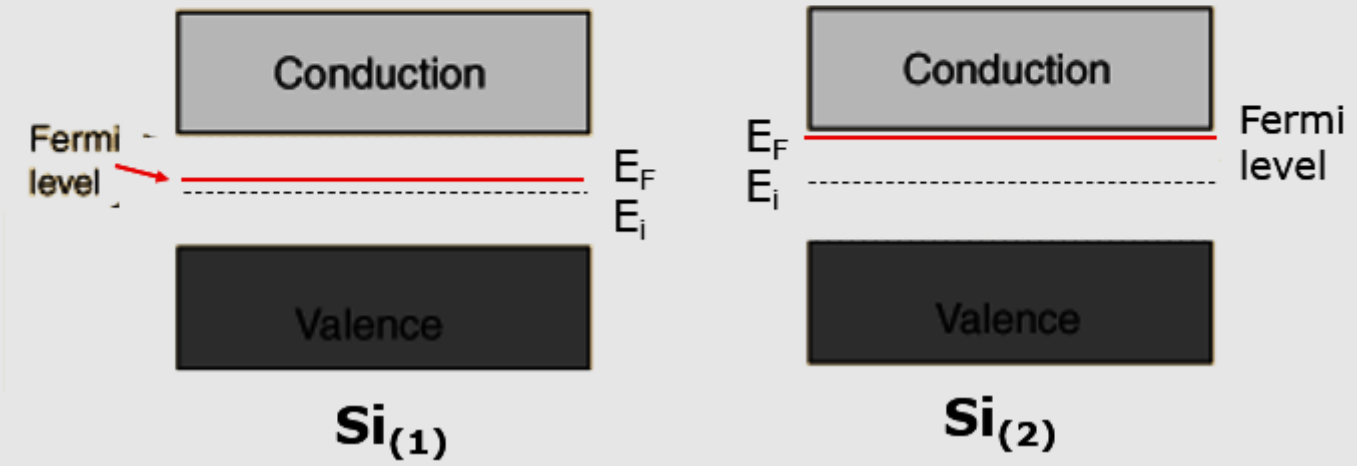
CT4

Energy band diagrams of two silicon materials, $Si_{(1)}$ and $Si_{(2)}$, are shown below and $(E_F-E_V)_{(1)} < (E_F-E_V)_{(2)}$,

Which one is true, compared with $Si_{(2)}$?

(A) $Si_{(1)}$ is a stronger p-type. (B) $Si_{(1)}$ is a weaker p-type.

(C) $Si_{(1)}$ is a weaker n-type. (D) $Si_{(1)}$ is a stronger n-type.



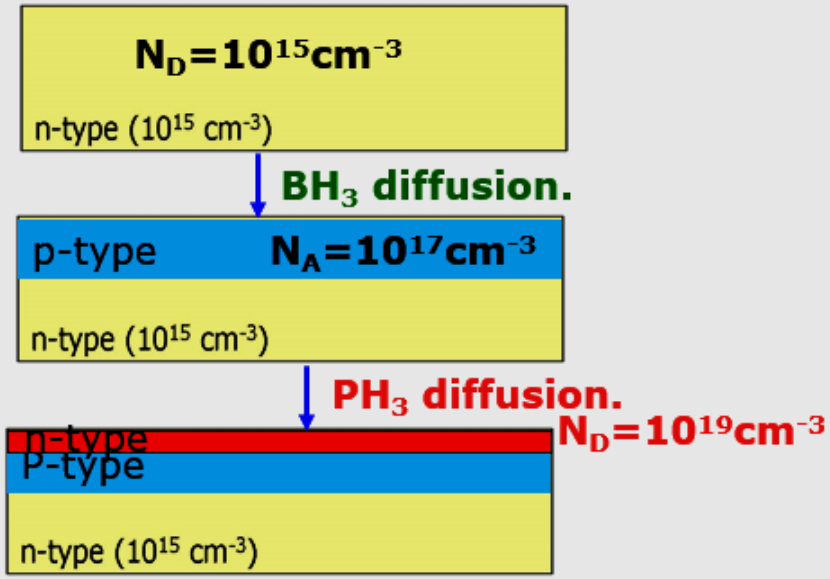
Section A (40%)

Example 3

CT12. Fig. shows a formation of npn transistor. After PH_3 diffusion, the hole density of the top layer is

(A) $10^{19}cm^{-3}$. (B) $10^{18}cm^{-3}$. (C) $10^{17}cm^{-3}$.

(D) $10^{3}cm^{-3}$. (E) $10^{1}cm^{-3}$.



Section B (60%)

Example 1

B1

Consider an intrinsic silicon (Si) sample at room temperature 300 K (i.e. 27 °C) in equilibrium condition.

(a). If the working condition of the Si sample changes to that with an operation temperature of 200 °C because of overheating, determine the intrinsic carrier concentration n_i in equilibrium.

(4 marks)

(b). If the intrinsic Si sample is doped with boron (B), what are the majority and minority carriers?

(2 marks)

(c). If the dopant concentration in (b) is 1×10^{15} cm^{-3}, determine the majority and minority carrier concentrations at room temperature 300 K. Please specify which concentration is for the majority carriers and which for the minority carriers.

(5 marks)

(d). Draw the energy band diagram for such a Si sample doped with boron (B). Please label clearly the conduction band edge E_c, the valence band edge E_v and the Fermi energy levels (including the intrinsic one E_i).

(6 marks)

(e) If the doped Si sample works at 200 °C because of an overheating condition, calculate the minority carrier concentration in equilibrium.

(3 marks)

Section B (60%)

Example 2

An inverter with a resistor load, R_L, is shown in Figure B, calculate the aspect ratio W/L, of the driver T_D, with the following specification:

i) the threshold voltage of the driver is $V_T = 1$ V,
ii) the device constant $\beta_0=\mu_n C_{ox} = 12.5\times10^{-4}$ AV^{-2},
iii) $R_L = 1$ kΩ,
iv) $V_{DD} = 5$ V.

(25 marks)

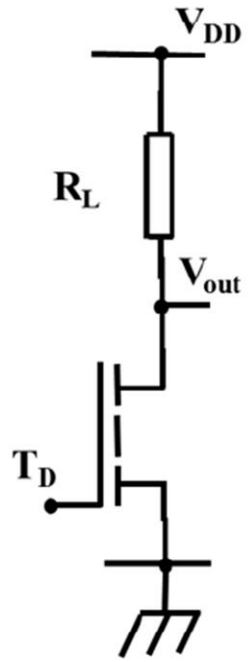


Figure B: Inverter with resistive load

Key-points of the module

- Capacitance *vs.* gate voltage characteristic of a MOS capacitor with n-type and p-type silicon substrate
- Energy-bands through an MOS capacitor
- I_D-V_{GS} curve and I_D-V_{DS} curve of an nMOSFET
- Drain current of nMOSFET
- Energy band diagrams of silicon materials
- Miller indices and yields
- Fermi energy level and Fermi function
- Diffusion constant and mobility
- Generation and recombination
- Doping element, materials and counter doping
- Hole concentration and electron concentration
- IC Technology: deposition, photolithography, doping, CVD, PVD

Key-points of the module

- **Semiconductor Fundamentals II**
- Intrinsic semiconductor
- Doping, majority free carriers, doping concentration

- **MOS Capacitor**
- Capacitor structure
- Energy band diagram
- Effects of applied bias
- Biasing conditions for p-type Si
- Biasing conditions for n-type Si
- High frequency or low frequency
- Block charge density diagrams

- **Technology**
- Photolithography
- Mask, process step
- Positive and negative photoresists

Extra Support

- **Key-points of the module**
- **MCQ Example Part 1** and **2** on Learning Mall
- **Extra Q&A Session** (not Compulsory, **in the reading week**)
  - Will announce in the learning Mall later
  - Please come to my office **SC342**


棒
XJTLU


佛
光
普
照

TIME TO SAY GOODBYE!
祝君好运、江湖再见！

Gary, Chun Zhao, PhD

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