# Home exam in Semiconductor Technology 2017

The exam consists of two parts, a fundamental part of the grade E and an advanced part for grade D to A. To get a higher rating, you must have approved in fundamental part. Fundamental part gives maximum 48 credits you will need at least 38 p for a grade of E, less gives grade F or Fx. With Fx means that you can supplement for higher grades. (F) Means that you have to redo the exam. Fundamental part rating is as shown in the table.

| | |
|---|---|
| 41-50 | A |
| 31-<41 | B |
| 21-<31 | C |
| 10-<21 | D |

Home exam must be submitted no later than November 13, 2017. Solutions should be clear and well justified.

Good Luck!

# Fundamental Part (3p/question)

1. Explain the photoelectric effect.
2. What do we mean by tunnelling in a quantum perspective?
3. What does it mean that there is an energy band gap in the semiconductors?
4. What happens if a semiconductor is illuminated with a photon energy less than energy band gap?
5. What happens if a semiconductor is illuminated with a photon energy larger than the energy band gap?
6. What describes the fermi level in a band diagram?
7. What describes the quasi fermi level in a band diagram?
8. What does it mean that a charge carriers have a certain diffusion?
9. Describe the occurrence of contact potential in a p-n junction.
10. To get a large injection of charge carriers in a diode needs.....
11. If you know the area and capacitance of a p-n junction what can be calculated?
12. A silicon diode has a leakage current. What components consist this leakage current of?
13. What similarities are there between a JFET and MOS transistor?
14. What are the essential differences between a JFET and MOS transistor?
15. What is a strong inversion in a MOS capacitance?
16. Describe the function of a bipolar transistor with terms such as injection, minority carrier recombination, forward bias p-n junction and reverse bias p-n junction.

# Advanced Part (10p/question)

17.is Draw a band diagram for Silicon doped with arsenic $10^{16}$ $cm^{-3}$ at temperatures 300 k and 600 k. View Fermi level and let it be based on the intrinsic fermi level (~middle of the bandgap) as energy reference.

18. A diode doped with $N_A = 10^{15}$ cm$^{-3}$ and $N_D = 10^{19}$ cm$^{-3}$. Calculate depletion width and the depletion on the p-side. How large is the contact potential? How large is the maximum electric field at 0 Volts as external voltage?

19.A Si p $^{+}$-n-p transistor have doping concentration $5x10^{18}$,$10^{16}$ and $10^{15}$ cm$^{-3}$ in the emitter, base and collector. Base width is W = 1 μm, and the cross-sectional area are 3mm$^2$. When the emitter-base transition is forward biased to 0.5 V and base-collector junction is biased to 5V, calculate:

a. the neutral base width
b. concentration of minority carriers in the emitter-base transition
c. Minority carrier charge in the base region. (eq 7-23 and figure 7-6)

20. For an ideal metal-$SiO_2$-Si diode having $N_A=10^{16}$ cm$^{-3}$ and oxide thickness of d =250Å ($\varepsilon r$=3.9), calculate the minimum capacitance, threshold voltage $V_T$ and the depletion charge in the semiconductor, assume strong inversion.

21. For an n-channel MOSFET with $Z$=30 um, $L$=1 um, $u_n$=750 cm$^2$/V-s, $C_o=1.5*10^{-7}$ F/cm$^2$, and $V_T$=1V find the $I_{Dsat}$ for an applied $V_G$ of 5V for the long channel case. What is $I_{Dsat}$ at velocity saturation (see eq 6-60)? Find the transconductance for this two cases.