Title

Written Exam with Six Tasks

Instructions

Edit Instructions

The exam should be completed in the 5 hour assignment period (8-13).
One extra hour until 14.00 is allowed to accommodate late submission due to any technical issues.
All answers should be handwritten and scanned into PDF-format.
Handwritten solutions using tablets are also OK if they are converted into PDF.
The following material is allowed:
[Material Properties and Formulas, spring 2020 version]
The standard rules and procedures for a written exam apply, see below for full information:

Written Exam
IH1611 Semiconductor Devices
Wednesday, June 3, 2020, 8.00
Open for submissions in Canvas until Thursday, June 4, 8.00

Write clearly and draw figures according to the instructions!
Sign your name on all answer sheets!
Use a new sheet for every task.
Examiner and responsible teacher: Gunnar Malm, 08-790 43 32

The student may use the following items during the exam: Calculator, ruler, and the attached ”Material Properties and Formulas”

Structure: *The exam consists of six tasks. To pass the exam you should fulfill the grading criteria to E level. Attempt all problems!*
Carefully read and consider all tasks at the start of the exam.

Students who do not pass the exam, and according to the judgment of the examiner are close to the pass limit, will be offered one chance to complement their exam and thereby receive a passing grade (E). No other grades are achievable in this circumstance.

If nothing else is stated in the tasks: Assume that the material is silicon (Si) and room temperature (T=300 K).

Add Content

Applications of semiconductor devices

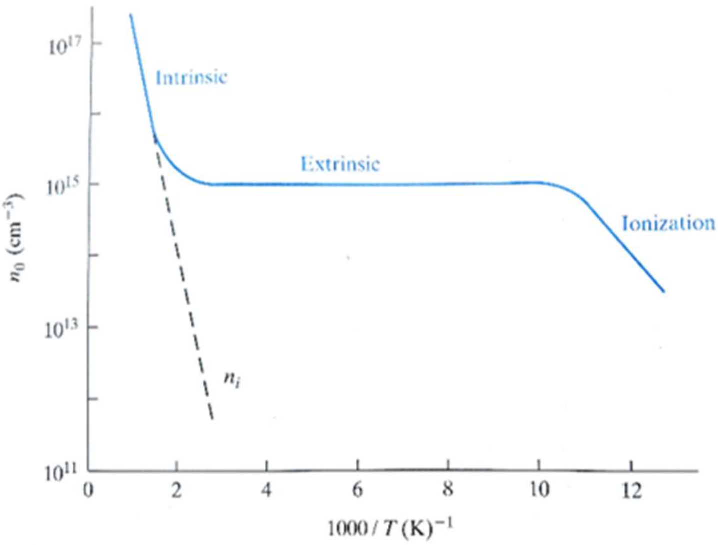
What types of semiconductor devices are used in a **hybrid electric car** like the one showed in the figure?

At least three examples are required!

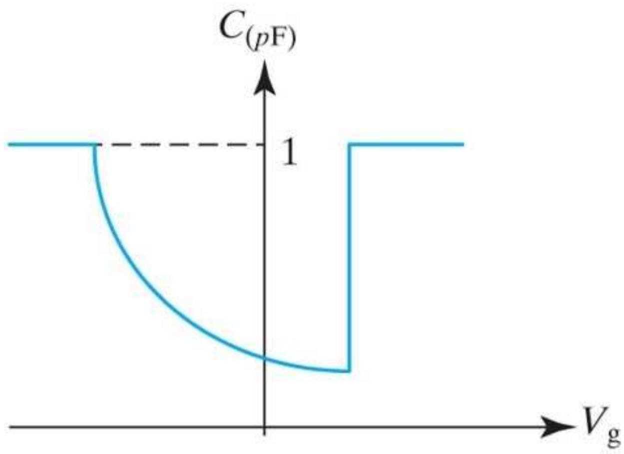
- name the type of the devices
- explain and motivate the most suitable semiconductor material for each device type
- explain if the devices are used "stand alone" or as part of more complex integrated circuits or memories

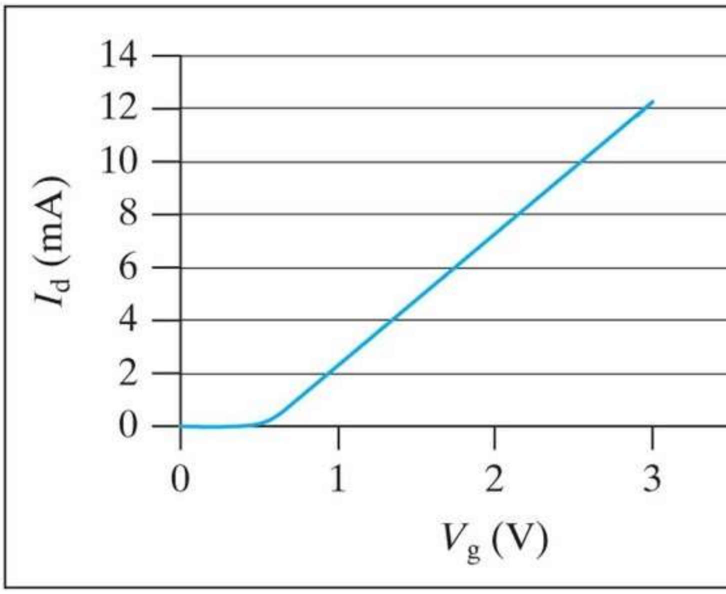
The carrier concentration in a doped piece of semiconductor material varies strongly with temperature. The figure below illustrates the carrier concentration in n-type silicon (10^{15} cm^{-3} of donors).
Draw a similar illustration for a piece of silicon-carbide (SiC) with an acceptor doping level of 10^{16} cm^{-3}.

Calculate some numerical values for the high temperature branch, the low-temperature behavior can be illustrated schematically.



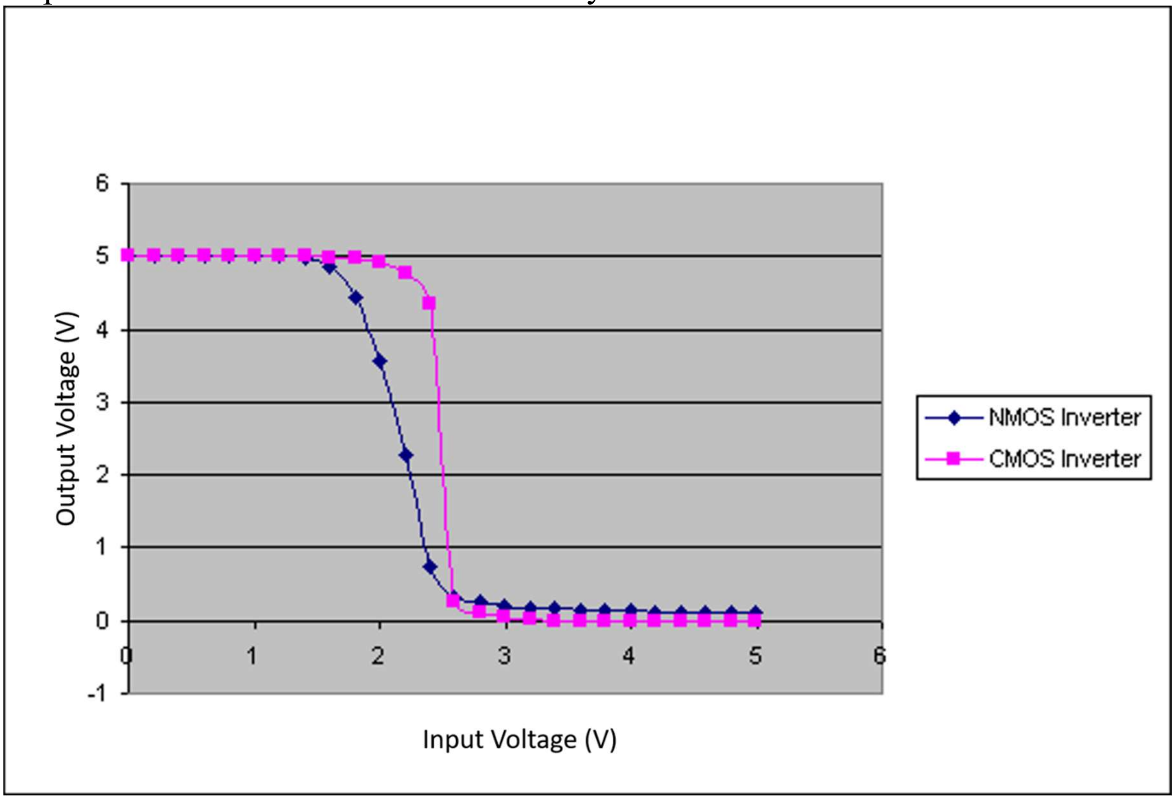
Determine the channel mobility of a MOS-transistor that has the IV-characteristics, shown in the figure below.
The CV-data are also needed.
Assume that V_{ds} = 100 mV and a channel length L_G of 1 micrometer (µm).





CMOS inverters have near ideal voltage transfer curves (VTC).
The figure below compares the VTC shape for a CMOS inverter and a so-called NMOS inverter with a resistive load.

Explain the differences and motivate why CMOS is a better choice.



Draw the full band diagram along the channel, from source to drain, for a MOSFET transistor.

- Illustrate both the NMOS and PMOS cases!

- Assume no applied drain bias $V_{ds} = 0$ V for one case
- Use an applied drain bias $|V_{ds}| > 0$ V for the other type of transistor
- Assume that $|V_{gs}| << |V_t|$ in one case and close to V_T in the other case

Assume an N-channel MOSFET with an N+ poly gate and a substrate with a very low doping close to the surface. Illustrated in the figure below.

Draw the energy band diagram of the MOSFET along the x direction from the gate through the oxide and the substrate, when the gate is biased at threshold voltage.
Since the P region is very lightly doped you may assume that the field in this region is constant.