

Problem 1 (6 points)

- 1.1 (1 point) What is the fundamental difference between metals and semiconductors? Semiconductors and insulators?
- 1.2 (2 points) What for doping of a semiconductor is used? Plot energy diagram of a semiconductor with donor and acceptor impurity levels.
- 1.3 (3 points) What mechanisms of photon absorption in semiconductors do you know? Draw schematics of the processes and explain the main differences.

Problem 2 (4 points)

- 2.1 (2 points) What physical parameters can be measured by using piezoelectric properties of materials? Draw schematic construction of the device(s). Explain what are the input and output signals, and how they are related to the measured parameter(s).
- 2.2 (2 points) How the resonant frequency of a piezoelectric device depends on the effective mass of the sensor?

Problem 3 (4 points)

- 3.1 (3 points) What is metal – oxide – semiconductor field effect?
- 3.2 (1 point) Give an example of devices using this effect.

Problem 4 (6 points)

Explain principle of operation, draw schematics of the device, input and output signals of the following magnetic field microsensors:

- 4.1 (2 points) Hall probe.
- 4.2 (2 points) Magnetodiode.
- 4.3 (2 points) What other magnetic field sensors do you know? Explain principle(s) of operation.

Problem 5 (5 points)

- 5.1 (2 point) Explain what is Coulomb blockade effect?
- 5.2 (2 points) Draw schematic of a Coulomb blockade thermometer. Explain what parameters should be measured, and how one can deduce the temperature from the measurements.
- 5.3 (1 point) What other types of low temperature thermometers do you know and what is the principle of their operation?