

ASE-3036 Microsensors (ASE-3030 Mikroanturit)

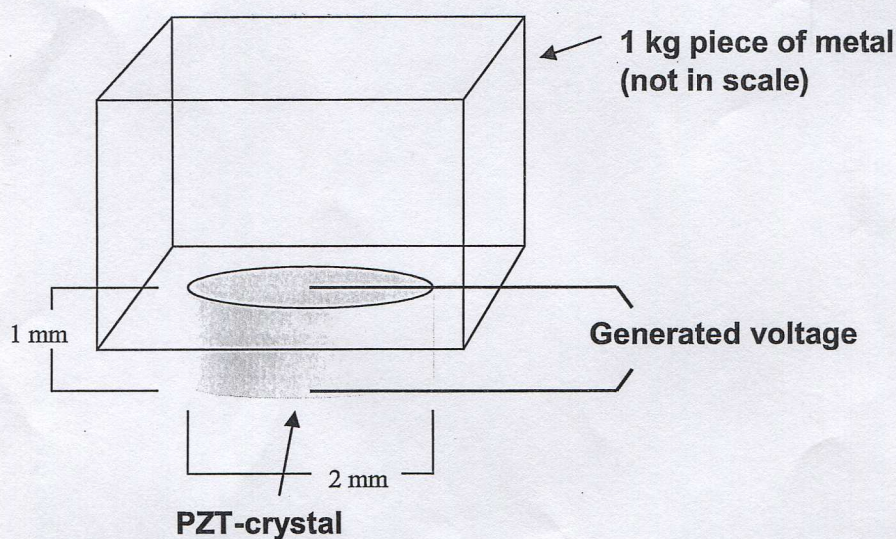
Exam on Mon 12.12.2016 at 13:00-16:00 at TB104

Exam responsible: Jukka Lekkala

Answer to all six questions.

*No written material is allowed.**All calculator types can be used.*

1. Explain shortly the following methods or conditions related to silicon micromechanics:
 - a. Anisotropic wet etching (3 p)
 - b. Self-terminating of the etching (1 p)
 - c. Self-alignment of the etching (1 p)
 - d. Etching of a convex corner (1 p).
2. Describe the two major methods of physical vapor deposition (3 + 3 p).
3. Explain shortly:
 - a. Photoelectricity and photodiode (1.5 p)
 - b. Photoconductivity and photoresistor (1.5 p)
 - c. Pyro electricity (1 p)
 - d. Magneto resistance (1 p)
 - e. Hall effect (1 p)
4. Piezoelectricity
 - a. Calculate the piezoelectric voltage that is generated by a cylindrical PZT (Lead Zirconate Titanate) crystal when a 1 kg piece of metal is placed on it. The diameter of the crystal is 2 mm and the height is 1 mm. Piezoelectric charge constant of the material $d_{33} = 400 \times 10^{-12}$ C/N and the dielectric constant is 1500. (2 p)
 - b. If the voltage is measured with some device, it starts to decrease. Why is that? (1 p)
 - c. A multimeter is used to measure the voltage. How long it takes before the voltage is decreased 90 % of its original value? The input resistance of the multimeter is 10 M Ω . (1.5 p)
 - d. What is the voltage constant g_{33} of the crystal? The unit of voltage constant is Vm/N. (1.5 p)



$$C = \epsilon_r \epsilon_0 \frac{A}{d}$$

$$V = \frac{Q}{C} e^{-\frac{t}{RC}}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m.}$$



5. a) What is the minimum diameter of a monocrystalline silicon wire that will support a weight of a 75 kg person? (2 p)
- b) What is the maximum strain of the monocrystalline silicon before it breaks? (1 p)
- c) How long wire of some material can you hang in earth's gravity field ($g=9.81 \text{ m/s}^2$) before it breaks under its own weight? Write your answer in terms of material properties i.e. derive an equation for the maximum length. (2 p)
- d) What is the maximum length in the case of silicon? (1 p)

Assume 160 GPa for the Young's modulus and 6.5 GPa for the maximum tensile stress (yield strength) of silicon. $E = \frac{F \cdot l}{\Delta l \cdot A}$, $\sigma = F/A$

6. Wheatstone bridge is commonly used together with piezo resistive sensing elements.
- a. What makes Wheatstone bridge convenient and useful? (2 p)
- b. Which kind of sensors it is commonly used with? (1 p)
- c. Derive the equation for the output voltage V_O of the Wheatstone bridge shown below. (3 p)

