MIT-4036 Microsensors Examination: November 24, 2008

1. How do generator and modulator type sensors differ from each others? Explain shortly the following sensor phenomena including explanation for the physical origin of the signal:
   a) piezoresistivity
   b) photoconductivity
   c) pyroelectricity
   d) piezoelectricity.

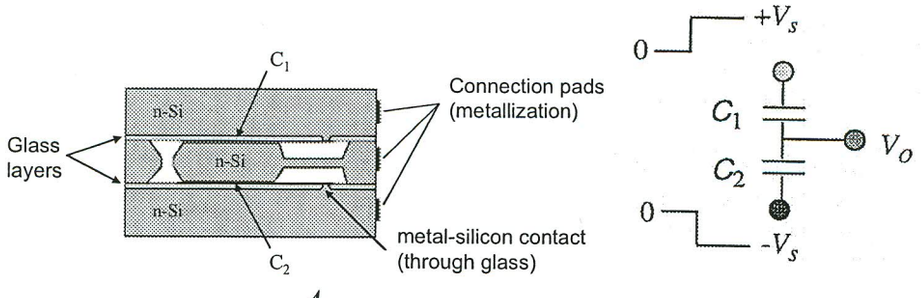
2. Why SiO_2 and Si_3N_4 layers are often needed in microsensors? How are these layers fabricated, and how does the processing method effect on their properties?

3. Explain, what means magnetoresistivity? Is it possible to use magnetoresistive sensors to measure the magnetic field of Earth (flux density appr. 50 μT)? How many sensors are needed and how should they be positioned to each others for an electric compass? Are some other sensors needed in that application?

4. Describe the structure and manufacturing principle of a micromechanical silicon microphone.

5. Explain the operational principle and measurement method of the accelerometer shown in Fig. 1. Derive equation which describes the relation between sensor output signal V_O and acceleration. What is the resonant frequency of the sensor, when the proof mass m = 200 μg and spring constant of the cantilever k = 3300 N/m? Draw a sketch for the frequency response of the sensor.

6. Present an electric equivalent circuit for a piezoelectric force sensor realized by using a quartz crystal. What is the time constant of the sensor? The arising voltage is measured from the crystal by using an amplifier, whose input resistance is 100 MΩ. What is the lower cut-off frequency of the measurement system (sensor + amplifier)? Relative permittivity of quartz is $\varepsilon_r = 4.5$, surface area and thickness of the crystal sensor are A = 1 cm^2 and d = 0.5 mm, respectively. Piezoelectric material constant and resistivity of quartz are $d_{33} = -2.3 \cdot 10^{-12}$ CN^{-1} and $\rho = 7.5 \cdot 10^{17}$ Ωm, rspectively. Permittivity of vacuum is $\varepsilon_0 = 8.85 \cdot 10^{-12}$ Fm^{-1}.



$$C = \varepsilon_0 \varepsilon_r \frac{A}{d}$$

Figure 1. Accelerometer.