Z49 - Biosensors

Physics Laboratory II – academic year 2017/2018
Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University

The goal of this exercise is to get acquainted with the optomechanical biosensor from Concentris. To detect biological interactions, elastic silicone cantilevers (dimensions $500\mu m \times 100\mu m \times 7\mu m$) are employed. These cantilevers bend or change their resonance frequency in response to external stimuli. These changes are measured with the help of optical detection system and then, they are transformed in position sensitive detector to the electronic signal. In this exercise, the resonance frequencies of cantilever vibrations are experimentally determined for microcantilevers of different dimensions. The experimental results are then compared to the theoretical, calculated values. Next, the average mass of single yeast cell, Saccharomyces cerevisiae, is determined using the analysis of resonance frequency change of the cantilever.

Preparatory questions

1. biosensor [1, 2]
2. cantilever microbiosensor – build and principle of operations [1, 3]
3. applications of cantilever microbiosensor [2, 3]
4. concepts of: resonance frequency, normal mode vibrations, Q (quality) factor of resonance curve, surface strain, bimetallic effect.

Computational assignments

Calculate the value of resonance frequency for first mode of vibrations of silicone cantilever with dimensions of $80\mu m \times 5\mu m \times 500\mu m$. Assume $E = 2,35 \times 10^{11} Pa$.

Apparatus and materials

Experimental setup and materials (with the system picture and element description):

- microcantilever sensor (Fig.1)
- set of microcantilevers
- holder with the sample mounting kit
- Yeast Saccharomyces cerevisiae

Student has in her/his disposal an oscilloscope, a PC computer and the copy of Teach Spin manual.

Experiment

- Exercise 1: determination of the resonance frequency of vibrations for cantilevers of different lengths and Q (quality) factor of resonance curves in liquid and gaseous environment.
- Exercise 2: determination of an average mass of single yeast cell Saccharomyces cerevisiae.
- Exercise 3 (optional): investigation of bimetallic effect.

Data analysis

Exercise 1
On the graph, show the dependence of measured amplitude of vibrations on frequency and fit Lorentz's model to every peak on the curve. Compare determined resonance frequencies for first 4 vibrational modes to the theoretically calculated values. Calculate the average Q factor for a given resonance frequency. Compare Q factor of resonance frequencies in water and in air.

Exercise 2
Calculations of single yeast cell mass. For this purpose you should:

- Determine the resonance frequency before and after mass deposition. It is necessary to include a graph of resonance frequency dependence on time for each cantilever.
- Determine the cantilever mass knowing the cantilever dimensions and table density of its material.
- Compare the determined mass with the literature data.

Exercise 3

- The difference in each cantilever bending should be calculated from obtained experimental data.
- The graph of the dependence of average cantilever bending on the magnitude of temperature change should be made for each cantilever.
- Compare the results for silicone cantilevers coated with the gold layer to the silicone only cantilevers.

Safety rules

It is advised to wear protective gloves during the work with yeast cells.

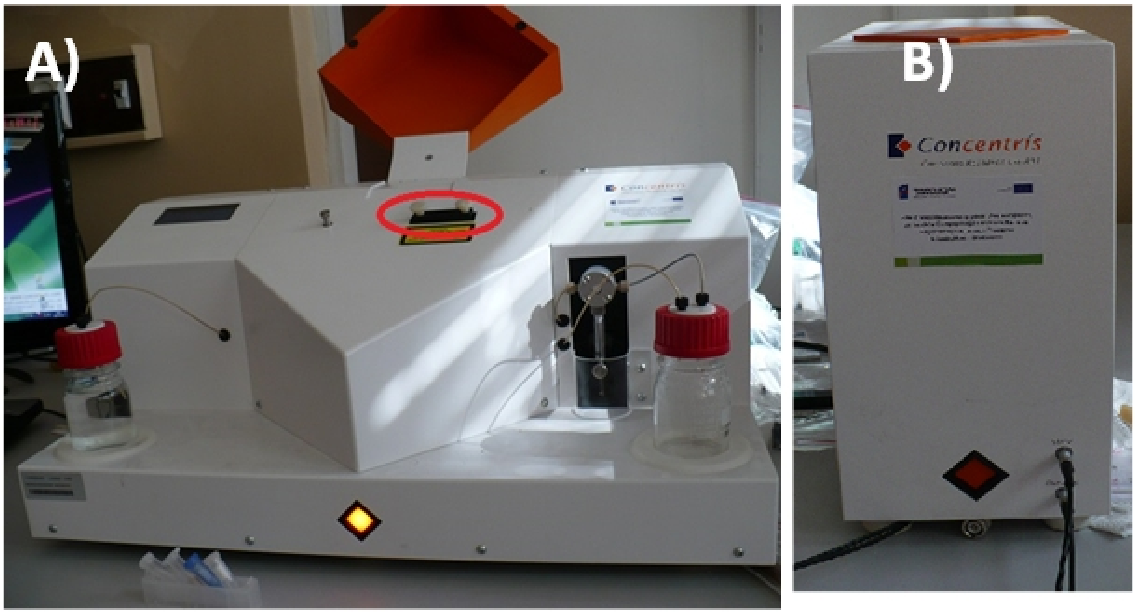

Figure 1: Experimental setup Cantisens® CSR-801. A – Main module, the red oval indicates place where cantilever holder with a set of cantilevers is inserted. B – Controlling unit.

References

[1] Instruction Z49 - materials in polish available on the www Adanced Physics laboratory after being logged in.

[2] M.Grattarola, R.Raiteri, H.J.Butt, P.Skladal, *Micromechanical cantilever-based biosensors*, *„Sensors and Actuators”*, 2001, nr 79 s.115-126

[3] H. P. Lang, C. Gerber, *Microcantilever sensors.*, Top Curr Chem. 2008;285:1-27. doi:10.1007/128_2007_28. s.1-12