MAE Fall 2006 (446.355)

Microelectromechanical Systems for Mechanical Engineering Applications

(마이크로기전시스템의 기계공학 응용)

Exam #2 Time: 4:30 ~ 6:00 12/06/2006

1. In general, there are two pumping methods in microfluidic devices using an external stimulus: pressure-driven flow and electroosmotic flow. (20 pts)

(1) Explain each pumping method. (5pts)

(2) Explain the dependence of flow rate on channel diameter for each pumping scheme. Which method is preferred in terms of flow rate and portability? (10 pts)

(3) Propose at least two ways to flow a liquid inside a microfluidic channel without using a pump (so called "pumpless flow"). (5 pts)

2. Let us consider four representative detection methods for BioMEMS: fluorescence, mass spectroscopy, surface plasmon resonance (SPR), quartz crystal microbalance (QCM). (20 pts)

(1) Fill in the blanks with "good" or "bad". (8 pts, 0.5 pts each)

Method / Feature	Fluorescence	Mass spectroscopy	SPR	QCM
Portability				
Labeling free				
Quantification				
Sensitivity				

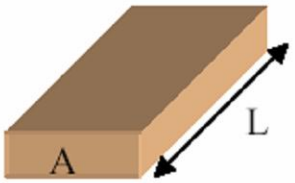
(2) In fluorescence microscopy, suggest two ways to reduce out-of-focus problem. (5 pts)

(3) In QCM, an increase in mass implies ( ) and thus one can monitor very small changes in mass in a very accurate manner. In SPR, light is reflected under certain conditions from a conducting film at the interface between two media of different ( ). The media are sample and glass of the sensor chip, and the conducting film is typically a thin layer of ( ) on the

chip surface. In mass spectroscopy, mass analyzers separate ions based on their ( ). Fill in the blanks. (7 pts)

3. (15 pts)

(1) Derive the gauge factor (GF) (= 1/ε×dR/R) for a rectangular beam with resistivity ρ where ν is the Poisson ratio and ε is the strain. Here, consider only the change of geometry by assuming that the resistivity is constant. (10 pts)



(2) The coefficient of performance (COP) in thermoelectric devices is defined as q_c/w where $q_c = (S_2 - S_1)IT_c - K\Delta T - 0.5I^2R$ and $w = (S_2 - S_1)I\Delta T + I^2R$. Explain qualitatively why each term should be written like this with proper physical meaning (S: Seebeck coefficient, K: Thermal conductance of the two legs, R: Electrical resistance of the two legs, I: Current density, etc.). (10 pts)

4. Briefly explain the following terms. (20 pts, 4 pts each)

(1) Fluorescent activated cell sorting (FACS)

(2) Seebeck coefficient

(3) Lab-on-a-chip (LOC)

(4) Enzyme-Linked ImmunoSorbent Assay (ELISA)

(5) Anodic bonding

5. (20 pts)

(1) Compare piezoelectric and electrothermal actuations in terms of fractional stroke, energy density and speed (7 pts).

(2) Suggest several mixing strategies (passive or active) in microfluidics. (7 pts)

(3) Explain why labeling-free cell sorting is important for biological studies. (6 pts)