Microfluidics and BioMEMS, Design task 2. 27.1.2021

Design task instructions:

Return as a single pdf document to the return box in my courses. **Maximum length of the answer is 1 page.** Formulae written with word or other text editor are preferred but I will accept hand written formulas and answers. If you do not have a scanner, then if you can take a good photograph and make a good looking pdf out of that then that is acceptable.

This task is worth 4 points on the course. Grading will be based on the following: 1pt the answer is correct, 1pt the presentation is clear, 1pt the reasoning and justification is clear and 1pt optimization of the design and other merits.

The main answer that you are returning is the design of a microfluidic chip that fits the criteria given in the task. The design means the dimensions of the microfluidic channel, and its architecture.

There is no single correct solution. You will get good points (about 3pt) if your design roughly satisfies the criteria and you have presented and justified the design well. You will get perfect points (4 pt) if I get the understanding that your design is close to optimal for the given task. **It is possible that satisfying all criteria given is impossible**, i.e. it is not possible to fulfill all of them. In that case, make your own best compromise and make it clear you have understood that this is the case.

In addition to just given the dimensions, add your calculations and reasoning to prove to me that your design is correct and that you have thought about the problem correctly. For example, if the instructions call that the maximum pressure can be 50 kPa, then have a pressure calculation to show that in your system the pressure is only 20 kPa, hence satisfies that criteria.

Task 2: (with bit of roleplay)

The deadline is 3.2.2021 10:00 (right before next weeks session).

Dear researcher X. We are a company that is developing immunodiagnostics for developing countries. A typical challenge is that there is no infrastructure for any kinds of laboratories, or pumps or even electricity sometimes. We are thinking to solve this issue by using a capillary filling immunodiagnostic platform.

Our main immunoassay channel is 20 µm wide, 20 µm high and 5 cm long and we know that its hydraulic resistance is about 10 MPa s / mm^3. We would like for you to design us some capillary pumps that could be used to obtain desired flow rates. One of our assays is best performed with around 1 nl/s flow rate, could you design that? We are also interested to hear what kind of range of flow rates could be possible with capillary pumps, some other assays we have could benefit from faster or slower flow rate.

You have the fabrication processes available to make rectangular cross section channel.

For both the height and the width, the smallest possible feature is 5 µm and the largest feature is 500 µm.

The materials you have are:

Glass: advancing contact angle 0°

Silicon: advancing contact angle 30°

PDMS polymer: advancing contact angle 110°

Due to fabrication limitations, only the following combinations are possible:

3 walls of the channel PDMS, the 4^{th} wall either silicon or glass (PDMS channel with a glass or silicon ceiling)

3 walls of the channel either silicon or glass, the 4^{th} wall out of PDMS (glass or silicon channel with a PDMS lid)

All 4 walls out of PDMS (fully PDMS channel)

As an answer, give the dimensions and materials of proposed capillary pumps, and the flow rates that they give with the immunodiagnostic chip.

Hints: You are free to assume that the flow resistance from the existing chip is so large that you do not need to take additional hydraulic resistance from your pump into account.

Start by playing around with materials and dimensions and calculate capillary pressures that you get (example for calculation is in class exercise 2, the full formula to use for rectangular channel when all 4 walls are of different material are in lecture 2).

When you get the capillary pressure calculated, check the flow rate by inserting your capillary pressure and the 10 MPa s / mm^3 resistance into Hagen-Poiseuille Q=P/R. Adjust the dimensions of the pump to obtain different flow rates.