Interdisciplinary STI Semester Project
Spring 2022

Lab in Tube Competition

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1. Project description

Objective:

The Lab In Tube project aims at producing a sensory tube capable of monitoring in real time the temperature and flow of a physiological-like fluid. The sensors should be prepared on a flexible plastic foil that can fit the inner tube and rely on heat transfer. Continuous read-out of the sensors' output should be monitored on a computer interface.

Context:

Microfabricated devices including MEMS and microelectronic circuits are traditionally prepared on rigid carrier substrates like silicon. Over the last 20 years or so, plastic substrates have progressively entered cleanroom process lines. Flexible electronics – sensors and circuits that can flex and roll – offer a new range of applications. In the biotech and medtech field, tubes, and catheters are widely used to carry fluids, blood, or bridge damaged tissue. Adding active sensing devices within the tube itself may allow for improved drug delivery or diagnostics. Designing, fabricating and characterizing such sensing devices require complementary and interdisciplinary expertise.

Two interdisciplinary teams of 4 students from distinct sections within STI/SV should gather to work on the competition. Towards the end of the semester, the 3 teams will compete against each other in demonstrating their Lab in Tube system in front of an inter-section jury.

The purpose of this interdisciplinary semester project is to:

1. Design and manufacture flexible thin-film sensors
2. Design and assemble a portable read-out interface
3. Acquire, process, and analyze experimental data
4. Work in a team
5. Communicate the results to others.

System requirement:

The Lab in Tube system will reliably monitor fluid temperature in the physiological range (35 – 45 ºC ± 0.1 ºC) and flow in the 10-100 mL/sec range. The sensor readout should be displayed in real time on a Labview interface or alike.

The device(s) will need to fit tubes of 10 and 5mm diameter (bonus will be obtained for devices fitting a 2mm diameter tube).

2. Working group

Student teams:

- **Team 1** (mentor Massimo Mariello)
  - David Niederhauser (MT)
  - Kateryn Leon (GM)
  - Elise Joulain (SV)
- **Team 2** (mentor Haotian Chen)
  - Clément Albert (MT)
  - Monika Stasytyte (SV)
  - Pierre-Jean Martin (MT)
- **Team 3** (mentor Yves Leterrier)
  - Ahmed Eman (SV)
  - Desire'E Maula' (SV)
  - Philippine Milward (MT)

Mentors:

Each team has a "mentor", who will guide and supervise the team throughout the semester.

Team 1	mentor: Massimo Mariello, massimo.mariello@epfl.ch, MX147, x31469
Team 2	mentor: Haotian Chen, haotian.chen@epfl.ch, Campus Biotech B3.2, x31019
Team 3	mentor: Yves Leterrier, yves.leterrier@epfl.ch, MXG 141, x34848

Experts:

"Experts" will guide the teams on each sub-topic (materials integration; microfabrication; electronics; testing) required to complete the competition.

Microfabrication	Materials	Electronics	Testing
NMP staff: Anthony Guillet Jemery Laedermann + Teaching assistants	Teaching assistants: Laurine Kolly Valentina Paggi Yash Vyza	Cedric Meinen (EL) Emilio Fernandez	Jean-Baptiste Leran Kangling Wu Haotian Chen

3. Where to work?

The Lab in Tube competition will use dedicated lab space in the Institute of Materials and the FCBG NMP (Neural Microsystems Platform).

Sensor design and fabrication will be conducted at the FCBF NMP, at Campus Biotech Geneva.

Electronic circuit design, assembly and test will be conducted in the dedicated lab space, MED 3 1715

Testing and characterization of your Lab in Tube system will also be conducted in MED 3 1715.

Each of the three teams has its own lab area with dedicated tools and equipment in MED 3 1715.

Useful link to some of the "Libre Service Ateliers" available on campus:

ELE 040: https://www.epfl.ch/schools/sti/ateliers/aci/

BM 4.206 and ME A.3.414: http://sti-ateliers.epfl.ch/page-42119-fr.html

4. Where to start?

Decide on how the team will operate: each team must define early on blocks of hours (at least 2 in a row) when all four members will be together to discuss the strategy, designs, and distribution of experimental work, etc. The teams will also agree on who will do what and how each member will inform the rest of the team on their progress.

Meet with your mentor: during the second week of the semester, each team will organize a meeting with a Mentor and agree on how often to meet with him.

Write a concise literature review on thin-film based microdevices used to measure temperature and flow in a liquid environment. The review must be submitted to your mentor.

5. Toolkits and materials

Each team will have at the start of the project the following:

Microfabrication toolbox (to be kept at the CMI+1 in the lockers in front of Zone 13):

Tweezers (x3)

Razor blades, scissors

Glass slides

Kapton tape, polyimide foils (A4 sheeting)

Experts will provide when needed:

Introduction on photolithography mask design using CleWin

Si wafers coated with sticky silicone rubber; "blank" Cr masks

Ordyl films (negative dry photoresist)

Training on the mask aligner and various wet benches

Metallization and parylene runs

Electrical toolkit (to be kept in MED 3 1715):

Cables, soldering station, etc.

Reference temperature sensors

National Instrument USB DAQ card

Fluke multimeters, Tektronix scope

DC power source and Function Generator

Experts will provide further advices when needed.

Characterization toolkit (to be kept in MED 3 1715):

Ag wire, Ag paste, RTV glue (to interface with the sensors on plastics)

Zeiss Stemi microscope

Flexi-tubing, water connection, hot plate, peristaltic pump…

A range of PVC half-pipes with diameters from 5cm to 2mm

6. Budget

Each team will be allocated a "virtual" budget of 2,000CHF to be used towards to completion of their demonstrator(s).

7. Reporting & Evaluation

Each team will:

- Report every other week (at least) to their mentor;
- Submit a short "state of the art" report to their mentor by mid-March 2022
- Give a mid-semester presentation to their mentor (1 speaker per team, 10-15min long), during the week of March 28 or April 3rd, 2022
- Write a project report where each student writes a section; one team leader can compile the intro and conclusion. The report should include a section providing a cost analysis of the project; reports should be handed in by June 11, 2022
- Give a final presentation (20min per team). during the week of June 13, 2022 (TBC)
- Compete against the other teams in validating and demonstrating their engineered system.

The final presentations and demos will be scheduled mid-June, 2022. The winning team (selected by vote from the "LiT mentors and experts") will receive a nice prize.

Each student will:

- receive an individual grade;
- collect the credits assigned by his/her own section for a Semester project.

Grading criteria:

40% final report

20% final presentation

20% demonstrator/prototype

10% project management

10% creativity and innovation

Tips for the final report:

The project report should be concise and scientifically sound. A good report should be easy and interesting to read. Do your best to write the report as if it were to be appear in scientific journal or a company technical report. Start early by writing the outline of the report, revise and improve it regularly.

The document should contain the following sections:

• **Cover Page:** include the title of the project, the team's name, the authors' names and their corresponding section, the date, and the name of your mentor.

• **Abstract.** Write a one paragraph (<200 words) summary of the report clearly presenting the project goal and challenges, methods and materials implemented to reach the goal, key results and a conclusion.

• **Introduction.** The introduction should be about 1 page and include brief background information on the problem, hypotheses to be tested, significance of the work, etc.

• **Background or Literature review.** This should be an updated version of the document produced at the start of the semester and discussed with your mentor.

• **Materials and Methods.** Describe materials, processes and experimental methods that you used to complete your project. This section justifies why you selected so and so materials, designs, circuits, etc. Present the calculations, characterization and measurement methods you have implemented to obtain the results.

• **Results.** Describe the measurements and simulation results (if there are any) that you have compiled. Illustrations, e.g. graphs, pictures or tables (with a reasonable number of columns & rows!), should be used and referenced clearly in the supporting text. Figures without written description are useless. To avoid extreme final Word file size, make sure to Paste As jpg or pdf your xls graphs, sketches, etc.

• **Discussion.** This is where you analyze and interpret your results. Their accuracy and reproducibility should be addressed. You can also include a section on how the results could be further improved.

• **Conclusion.** This is typically a one page summary of the work, stating what was learned, implemented and how this work could be expanded and/or applied to a specific context.

• **Appendix on team and budget management.** This should be described in one page. It should include how you worked as a team and how your project budget was managed. This is also where you can say who wrote which section of the report.

• **Other appendix.** Include relevant technical information.