Lab project M1 PPN & QuanTEEM

04/05/2026 – 19/06/2026

Title of the project:

Numerical simulation of microfluidic flow (in COMSOL) - Application to biosensing.

Supervisor(s): G. Colas des Francs, A. Leray, K. Hammani, L.Markey

Laboratory / Department / Team : ICB / Nanosciences & Photonics departments

Collaborations:

Scientific Context :

Integrated optical waveguide sensor prototypes based on plasmonics are ultra-sensitive, allowing to detect traces of a given analyte from a real sample in a specific manner [1]. In these biosensors, target molecules bind on the sensor's surface to immobilized probe molecules (e.g. proteins, antibodies) pre-deposited on the surface by a chemical functionalization technique. The real sensitivity of the biosensor corresponds to the minimal concentration of target molecules the instrument is capable to detect. It is an essential characteristic of the biosensor and is resulting from various factors, including the optical bulk sensitivity, the affinity constant between the probe and the target, and also the quantity of target molecules that interact with the sensor's surface area. This quantity depends of the 3D distribution of the target analyte inside the flowing liquid. In ICB, we develop microfluidics modules to transport the analyte solution in a controlled way at the location of the sensors. The design of the microfluidics (MF) has an important role in improving the real sensitivity. One of our objective is to explore different MF designs by studying the binding kinetics of a given biomolecular surface interaction. As in MF systems the flow is usually laminar, only a very small fraction of the targeted molecules actually can be found in the effective surface detection area, thus is a limiting factor for sensitivity. Therefore, to increase the sensitivity; we want to force a localized turbulence of the fluid to redirect the particles to be detected as close as possible from the detection area.

Numerical simulation is a great tool to help us predict the efficiency of new designs and to interpret the experiments.

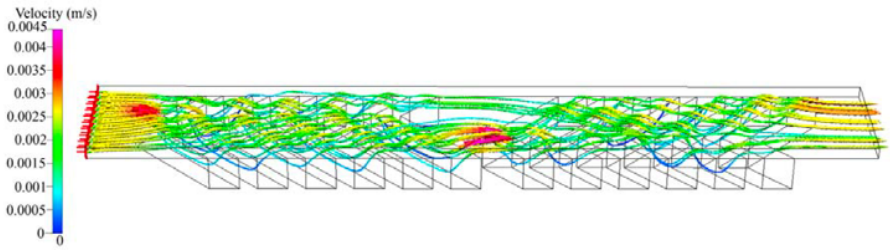

Fig. 1. Modification of the fluid velocity in structure microfluidics channels. The grooves width are 100 µm. From Lab Chip **12**, 2634 (2012).

Objectives and content of the internship:

The main objective of the internship is to simulate in a finite-element method software (COMSOL) the flow of particles in microfluidic channels and compare with current experiments. Various designs can be studied, including complex 3D shapes that are susceptible to be fabricated by 3D microlithography [3-4].

Additional note: On the same scientific theme, another M1 internship is also proposed, but dedicated to experimental development.

References :

1. Markey L. et al. Des capteurs plasmo-photoniques pour la sécurité sanitaire des produits agricoles, Photoniques 135 , 39-43 (2026). https://doi.org/10.1051/photon/202412938

2. Gale, B. K. et al. A Review of Current Methods in Microfluidic Device Fabrication and Future Commercialization Prospects. Inventions 3, 60 (2018).

3. Golvari, P. & Kuebler, S. M. Fabrication of Functional Microdevices in SU-8 by Multi-Photon Lithography. Micromachines 12, 472 (2021).

4. Oellers, M., Lucklum, F. & Vellekoop, M. J. On-chip mixing of liquids with swap structures written by two-photon polymerization. Microfluid Nanofluid 24, 4 (2020).

Type of project (theory/experiment): numerical simulation

Required skills: