Lab project M2 PPN

Monday & Tuesday from Nov. 2026 to March 2027

Title of the project: Microfluidics benchmarking to enhance biosensing at the surface of glass by fluorescence microscopy.

Supervisor(s): Laurent MARKEY

Laboratory / Department / Team : ICB / Nanosciences

Collaborations: Elise Mignon, ARCEN Nanofab team, R. Al Rafrafin (ICB Smartlight) and Multilab project's partners if needed

Summary:

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 immobilize and 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 (MF) modules to transport the analyte solution in a controlled way at the sensor's location. The design of the microfluidics plays an important role in improving the real sensitivity. One of our objective is to compare 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. To increase the sensitivity, we modify the distribution of the particles in the MF channel by a localized turbulence of the fluid as close as possible from the detection area.

Objectives and content of the internship:

The main objective of the project is to fabricate microfluidic modules with internal stirring structures and compare their performance in terms of binding kinetics. The experiments are performed on a fluorescence microscopy setup combined with microfluidics. Molecular binding experiments are performed at the surface of glass with a flow of fluorescent micro or nano-particles (targets). Qualitative and quantitative estimations are obtained by analyzing the images and particles-counting.

The MF modules will be fabricated either by PDMS molding from a master mold, which can be prepared by optical lithography (maskless) of SU8 photoresist, or directly in the SU8 resist. Additional 3D stirring microstructure may be added inside the microchannels by two-photon polymerization in a 3D microlithography equipment (Nanoscribe, platform Smartlight). Surface chemical functionalization protocols will have to be applied to prepare the surfaces before the binding experiments.

Main activities : Fluoresence microscopy microfluidics combined experiment - Microfluidics fabrication – Surface chemical functionalization.

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): experiment

Required skills: microfabrication / lithography / microfluidics / fluorescence microscopy / image data treatment