Thesis: *Optofluidic microsystem for the measurement of single cell mechanical properties*

Research Unit: Institut des Nanotechnologies de Lyon (http://inl.cnrs.fr/en)
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Scientific field and context: The diagnosis of most pathologies is currently carried out on the basis of biomolecular tests. However, in the context of point of care diagnostic, where low-cost devices are needed, these techniques suffer from certain limitations. Indeed, the use of biomolecular reagents can be quite expensive, requires strict conservation conditions and imposes a limited life of the device. To overcome these disadvantages, it is necessary to develop new approaches exploiting the physical properties (mechanical, electrical or migratory properties of cells). This thesis aims to provide an innovative approach to perform a diagnosis through the combination of nanophotonics and microfluidics. It is based on an optical measurement of the deformability of individual cells, which is an indicator for pathologies such as malaria, cancer, sepsis, etc...

Keywords. *Microsystem, Nanotechnology, Photonics, Diagnostics, Deformability*

Objectives of the thesis: We want here to study the mechanical properties of individual cells for the diagnosis of malaria. Our approach is based on the generation, already demonstrated at INL, of very intense optical forces (amplification by a factor of 1000 compared with conventional optical traps) using big photonic crystals resonant cavities (surface area between 5 µm and 5 µm and 20 µm x 20 µm) in a fluid medium. A schematic diagram is shown in Figure 1. It is a ***photonic chip integrated into a microfluidic circuit***. A laser source excites the photon resonance and thus generate, on the surface (about 100 nm thick), an intense and extended photonic mode (larger than that of the cell). This mode will induce optical forces that will attract the cell to the surface of the sample. This allows an optical reading of the deformation: one can follow in real time the deformation of the cell with a nanometric precision. In addition, it is possible to selectively trap the cells of a given shape and thus perform a sorting.

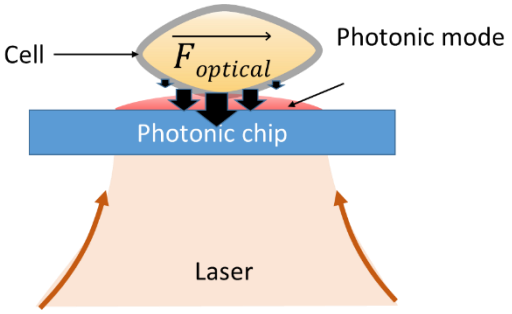

Figure 1 Schematic diagram of the micro optical system (the system is integrated with a fluidic circuit)

Scientific supervision:

Since the thesis is of a multidisciplinary nature, it will be based on two complementary INL teams, namely the Nanophotonics team for the optical part and the LOCI team for the microfluidic part. Both teams are internationally recognized for their expertise. This thesis must generate new synergy in the laboratory. It fits perfectly into one of the three major issues of the laboratory: Microsystems, sensors and sensor networks for health.

The scientific supervision will consist of:

Taha BENYATTOU, DR CNRS, Nanophotonic Team 50%

Magalie FAIVRE, CR CNRS, LOCI Team 50%

Candidate Profile:

A strong background in physics is required for this subject with very good records of academic performance. The candidate must have interest for experimental physics. Notions in nanophotonics, microfluidics or technology will be appreciated**.**

Skills that will be developed during the PhD:

This thesis must enable the PhD student to acquire an extended multidisciplinary expertise in:

(i) nanophotonics: from the design of optical components (FDTD modeling, RCWA ...), their realisations and integrations thanks to nanotechnological processes (nanolithography, etching techniques…) and their optical characterizations (micro reflectivity, imaging and signal processing ...).

(ii) microfluidics: from the design of microfluidic chips (CLEWIN ...), their fabrication in a clean room environment (soft lithography, replicat molding…) and their coupling with the photonic crystal resonant cavities.

Moreover, the PhD student will benefit from the technological facilities provided by INL (100m² clean room + 40m² cell culture and bio manipulation) and gain training in various areas including: manipulation of blood samples, cell mechanics and image analysis (Matlab®).

Professional prospects after the thesis:

This thesis is a good springboard to a career in the academic field. The multidisciplinary aspect is a guarantee not only of scientific quality, but also of a stimulating scientific environment. This cutting-edge subject will be easily promoted in terms of publications and international conferences.

As far as a career in the industrial field is concerned, the acquired skills can be easily valued, in particular the experimental skills, in characterization and nanotechnology that are highly valued in microelectronic industries.

Bibiography

NanoOptical tweezers :

L. Milord thesis « Dispositifs photoniques innovants pour le piégeage optique : Cavité étendue à double période et structure hybride cristal photonique-nano antenne » 2016 *https://tel.archives-ouvertes.fr/tel-01503154*

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Microsystem for the measurement of cell deformation :

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