Bacterial stress monitoring with optical micro-resonators

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With the appearance of multi-resistant bacteria in recent years, the situation is rapidly worsening when it comes to infectious diseases, which are predicted by the WHO to become the leading cause of mortality by 2050. In view of this, the priority objective is to optimise the use of antibiotics and to evaluate the possibility of using other antimicrobial agents such as phages. New, faster and cheaper diagnostic tools should contribute to this by allowing the delivery of an adapted and personalized anti-infection therapy as quickly as possible. It is in this context that the advent of micro- and nanotechnologies opens new opportunities to investigate rapidly the physicochemical properties of individual bacteria in order to propose innovative diagnosis methods.

The force exerted by light, when it encounters or traverses matter, allows moving or manipulating objects of micrometric size.[1] This is generally implemented through a microscope, and the setup is called in this case optical tweezers. This principle has recently been transposed on-chip thanks to the implementation of micro-cavities and photonic crystals allowing highly confined light intensity at the wavelength scale (Fig. 1). It then becomes possible to consider the non-destructive trapping and characterization of bacteria at the single cell scale.[2]

Here, the proposed work will consist in realizing optical characterization of dedicated photonic chips and to use them to trap and analyse individual bacteria in solution. The influence of an external agent (antibiotic, phage or heat) on the photonic response of the individual bacteria will be monitored live. We believe that such photonic systems open the way to a very rapid diagnostic tool.

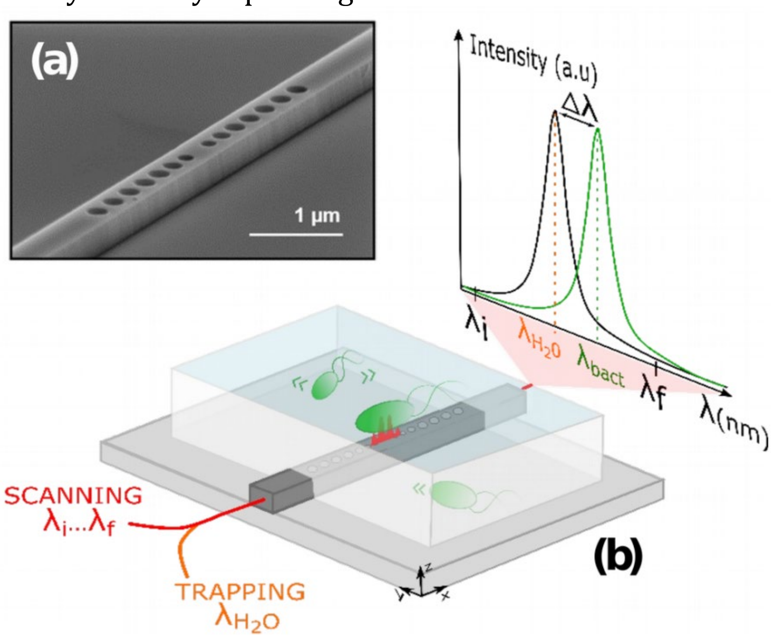

Figure 1. (a) Optical micro-resonator visualized with SEM, (b) schematic diagram: the bacteria is trapped in the evanescent wave above the resonant micro-cavity. The trapping affects the resonance frequency and thus the transmitted signal trough the micro-cavity.

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[1] A. Ashkin et al. Observation of a single-beam gradient force optical trap for dielectric particles, Opt. Lett. 11, 288-290 (1986)
[2] R. Therisod et al. Gram-type differentiation of bacteria with 2D hollow photonic crystal cavities, Appl. Phys. Lett. 113, 111101 (2018)