ON-CHIP OPTICAL NANOTWEEZERS FOR BACTERIA AND BACTERIOPHAGES VIRUSES TRAPPING AND SUSCEPTIBILITY TESTING

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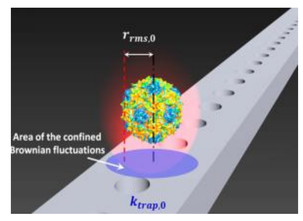
Optical photonic crystal microcavities (PhC) allow on-chip strong light localization and provide an efficient way to perform optical trapping of nano-objects. Since trapping occurs in the near field of the optical resonator, the presence, nature and even residual movement of the object within the trap leads to a direct modification of the resonant frequency of the optical cavity that can be monitored in real time. Using such on-chip nanotweezers, we previously demonstrated the trapping, manipulation and gram-type identification of bacteria [1-3].

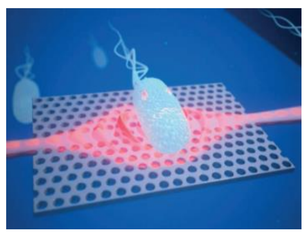
Here we show results towards a new method to perform antibiotic or phage susceptibility tests with single phages or bacteria trapped in an optical chip. The system contains a photonic chip topped by a microfluidic system allowing the transport of bacteria and phages. We report that phages can be trapped as bacteria. Moreover, we also observe a characteristic signal corresponding to bacterial lysis.

STATE OF THE ART

Biological objects

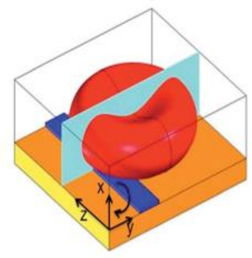
Virus : 100 nm
P. Kang *et al.*, *Scientific Reports* (**2015**).



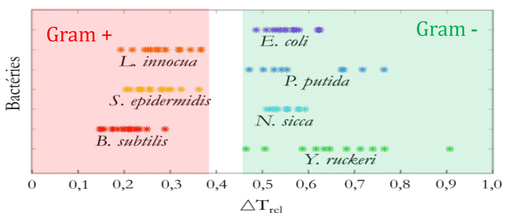


Bacterium : 1 µm
T. Van Leest *et al.*, *Lab Chip* (**2013**).

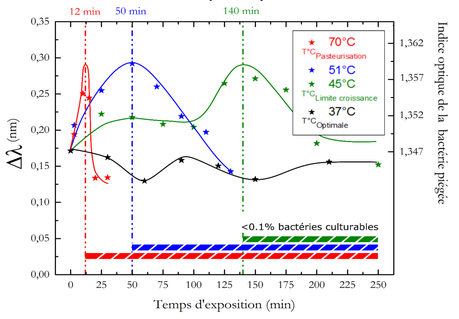
Cell : 10 µm
B. Singh Ahluwalia *et al.*, *Analyst* (**2015**).



▶ **LABEL FREE NON DESTRUCTIVE GRAM TYPING:**
- R. Therisod, M. Tardif, P. R. Marcoux, et al *Appl. Phys. Lett* (***2018***)

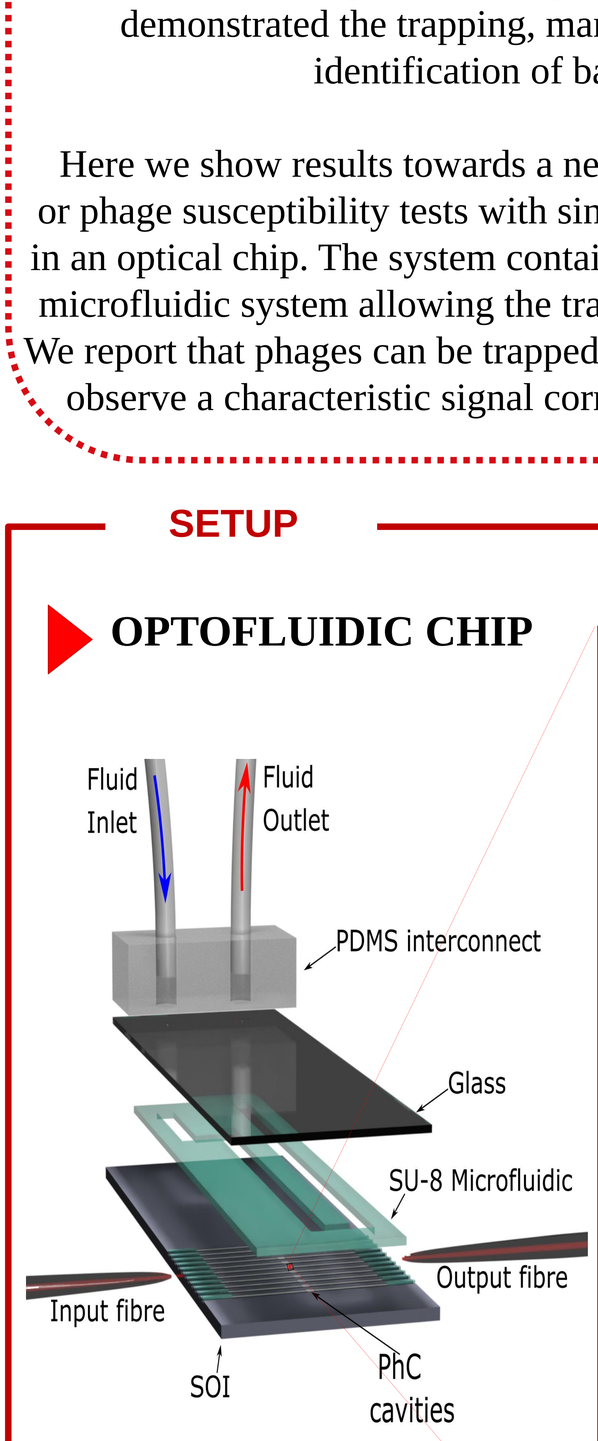


▶ **EFFECT OF THERMAL STRESS:**
- M. Tardif et al, *Small* (***2021***)

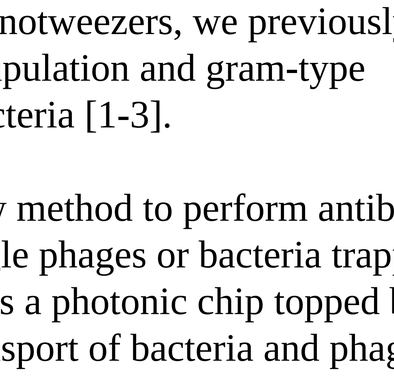


SETUP

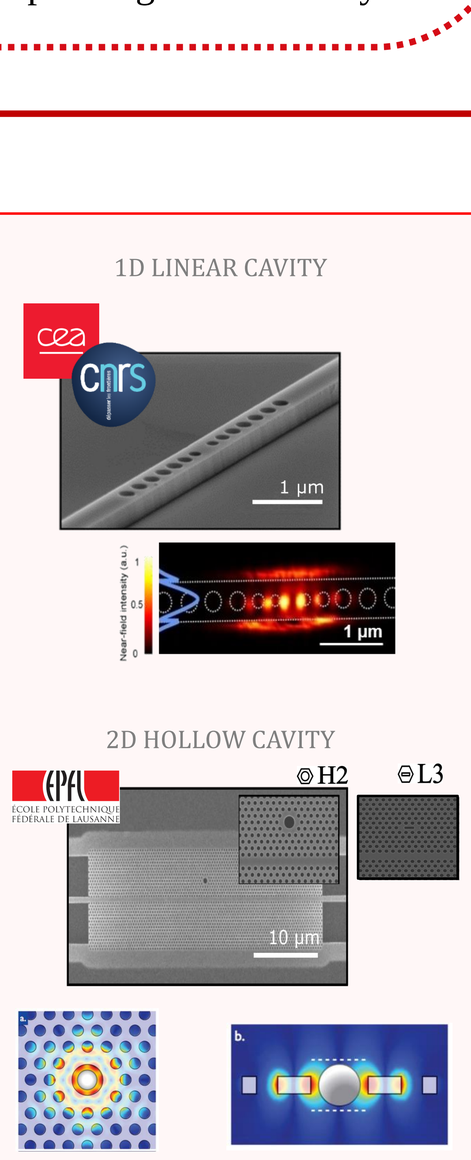
OPTOFLUIDIC CHIP



1D LINEAR CAVITY

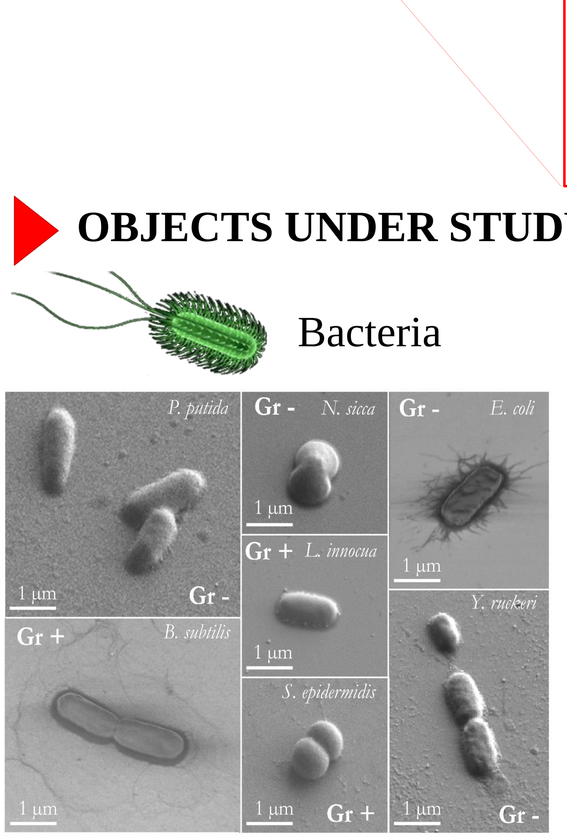


2D HOLLOW CAVITY

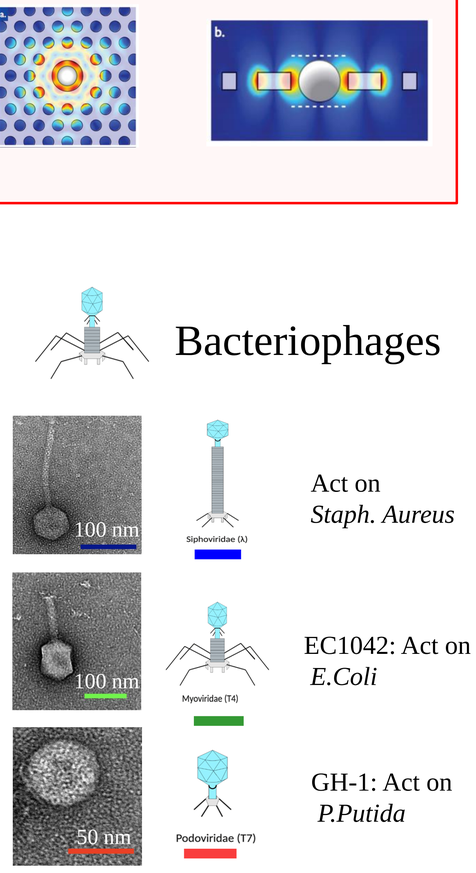


OBJECTS UNDER STUDY

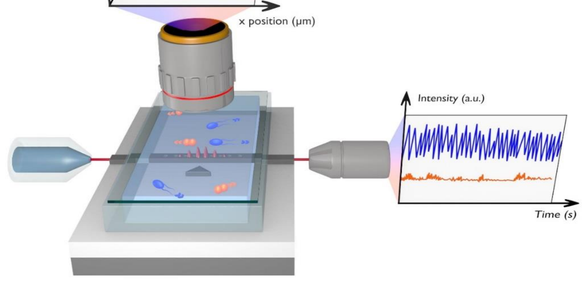
Bacteria



Bacteriophages

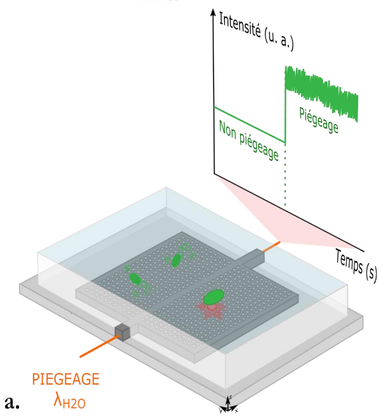


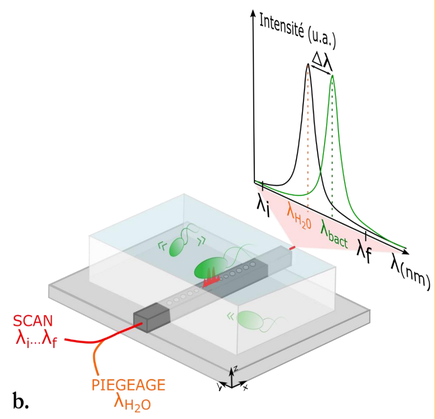
PRINCIPLE OF TRAPPING



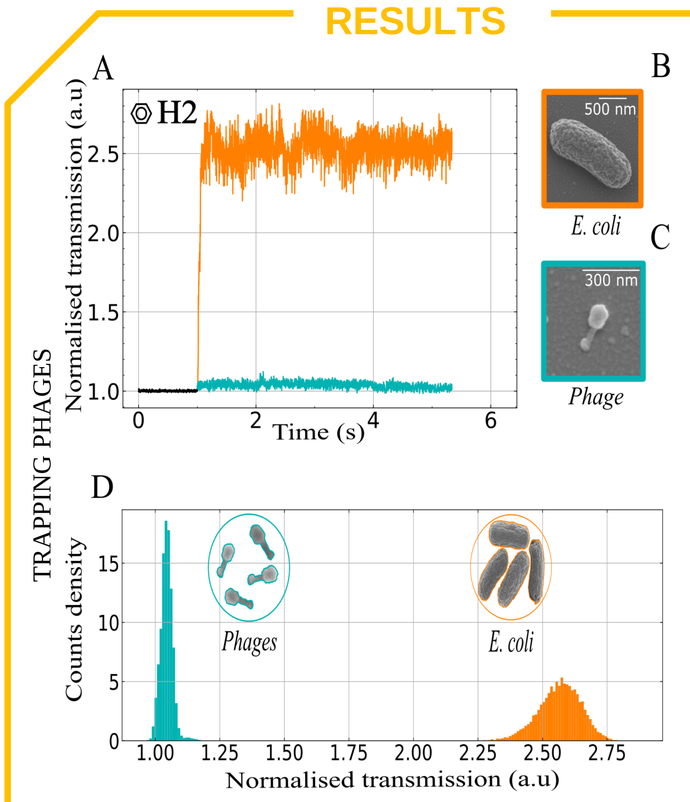
SYNCHRONIZED SPATIAL AND TEMPORAL CHARACTERIZATION

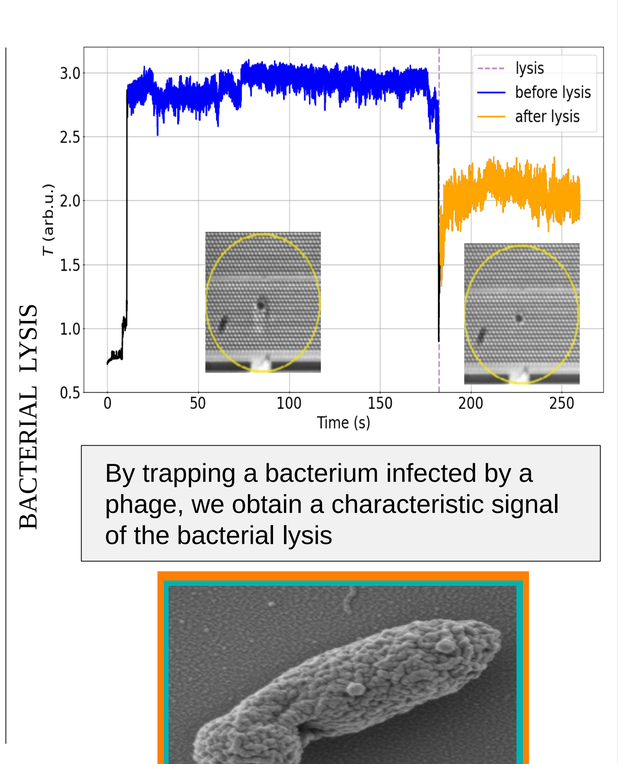
TRANSMISSION SIGNAL IS RELATED TO RESONANCE SHIFT





RESULTS





By trapping a bacterium infected by a phage, we obtain a characteristic signal of the bacterial lysis

A :Trapping signal for *E.Coli* and *EC1042* on H2 cavity
B,C: TEM images , D: Histograms obtained with n=10 events

[1] M. Tardif et al. "Single-cell bacterium identification with a SOI optical microcavity." Appl. Phys. Lett. 109.13 (2016): 133510.
[2] R. Therisod et al. "Gram-type differentiation of bacteria with 2D hollow photonic crystal cavities." Appl. Phys. Lett. 113.11 (2018): 111101.
[3] M. Tardif et al. "On-Chip Optical Nano-Tweezers for Culture-Less Fast Bacterial Viability Assessment." Small 18.4 (2022): 2103765
[4] A. Gordillo et al. ”Phage therapy in the postantibiotic era.” Clinical microbiology reviews 32.2 (2019): e00066-18.

We believe that such on-chip nanotweezers may open the way to ultrafast antibacterial susceptibility testing since the test can be performed on very small biomasses and at the single-cell level. This novel technique would help the consolidation of phage therapy, which will play a crucial role in fighting against the problem of antibiotic resistance [4].