

TIME (DO NOT FILL IN)

**INFRARED NANOSCOPY DONE BY PHOTOTHERMAL INDUCED RESONANCE
TECHNIQUE : APPLICATION IN MICROBIOLOGY**

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We have developed a new infrared spectromicroscopy technique, called PTIR (PhotoThermal induced Resonance, Patent US11/803421) [1], based on the coupling between a tunable infrared laser and an AFM (Atomic Force Microscope). This coupling allows us to perform ultra-local infrared spectroscopy and chemical mapping at the nanometric scale. The principle is based on detecting the local thermal expansion of the sample, irradiated at the wavelength of its absorption bands. This expansion is detected by the AFM tip in contact mode. As the duration of expansion and relaxation of the sample is always shorter than the response time of the cantilever in contact, the excitation transmitted to the cantilever is close to a delta function, so that it always oscillates at its own resonance frequencies. By recording the amplitude of these oscillations we can measure the corresponding infrared absorption as a function either of space or wavelength. We have validated this technique by comparing the infrared spectrum of a single *E.coli* bacterium and the corresponding FTIR spectrum, showing the possibility to perform chemical mapping with sub-wavelength spatial resolution [2,3]. Later, similar outcomes have been obtained in nanophotonics [4].

Presently, our work is mainly focused on microbiology systems [5]. The strong constraint of the biologist is often to study living samples in their common environment. To fill this conditions, we have developed our technique to work in liquid (AFM liquid scanner) with a constant temperature (Peltier device). The first results have been really encouraging : we have recorded the spectrum of the glycogen band (1080 cm^{-1}) of one *Candida Albicans* blastospore in water and the corresponding chemical mapping, despite the fact that the liquid water is absorbing in this range. The next step is to perform series of measurements on one bacterium to follow its growth in real time by mapping the sample at the amide I band until its division. The succeed of such experiments led us to propose to biologist users a technique adapted to their thematic mixing infrared studies and "in vivo" experiments.

Since two years, the PTIR technique associated to the CLIO infrared FEL facility (http://clio.lcp.u-psud.fr/clio_eng/clio_eng.htm) is proposed to users as a standard beam line (called AFMIR). In addition, in order to compensate for the limited availability of the CLIO FEL and to complement it in the short wavelength range we added to our experiment an infrared OPO laser allowing us to work permanently from 4000 to 2500 cm^{-1} .

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