Controlled deposition and characterization of single bacteria using nanomechanical sensors in air

Alicia Aparicio-Millán
Eduardo Gil-Santos, Jose Jaime Ruz, Sergio García-López, Priscila Monteiro Kosaka, Montserrat Calleja, Javier Tamayo

Instituto de Micro y Nanotecnología (IMN-CNM, CSIC), C/ Isaac Newton 8 (PTM, Tres Cantos), Madrid, Spain

alicia.aparicio@csic.es

Abstract

Nanomechanical resonators have emerged as excellent tools in microbiology due to their extraordinary capability to characterize the mass and mechanical properties of a variety of microbiological entities [1]. These sensors have allowed to detect, characterize and identify individual bio-entities, such as human cells, bacteria, viruses and proteins. Meanwhile researchers have succeeded on characterizing individual cells in liquid environment, single viruses or proteins applications have been limited to vacuum condition, mainly due to their small sizes, thus, being far from their intrinsic conformation.

In this work, we present a novel technique based on the use of commercial microcapillaries, that allows to deposit individual bioentities on controlled positions of the sensors (Figure 1) with micrometric precision in air conditions [2]. We accurately characterize the mass and mechanical properties of different types of alive bacteria that are close to their intrinsic conformation. We achieve it by simultaneously tracking multiple mechanical resonance frequencies of the sensors and analysing the changes induced by bacteria adsorption (Figure 2).

Importantly, this technique may find applications for a great variety of analytes and wide diversity of sensors. In addition, besides being extremely useful for quick analyte characterization, it may offer a vast variety of applications, such as, accurate sensors calibration to increase their reliability or to test the sensors capabilities.

References

[1] J. Tamayo, et al. "Biosensors based on nanomechanical systems". Chemical Society Review, 42 (2013) 1287.

[2] A. Aparicio-Millan, et al. "Controlled deposition of individual and alive bacteria onto nanomechanical resonator sensors for their characterization in air". *In preparation.*

Figures

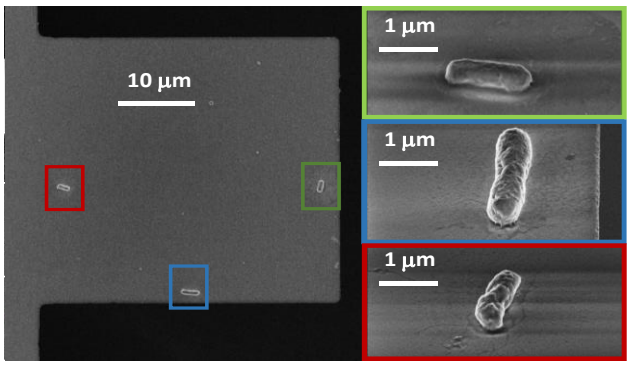

Figure 1: On the left: Scanning Electron Microscope (SEM) image of a squared resonator (40 µm length and width, 100 nm thickness) with three Escherichia Coli bacteria deposited on different targeted positions. On the right: Zoomed SEM images of each event.

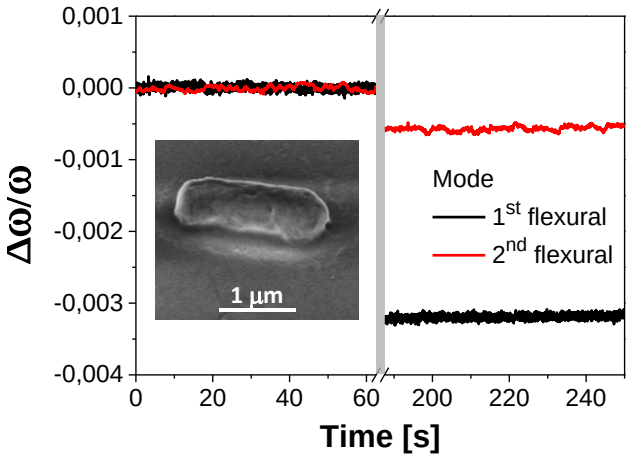

Figure 2: Relative frequency shift of the two first flexural modes of the squared resonator induced by the adsorption of an Escherichia Coli on the free end of the resonator.