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JAVIER TAMAYO

CSIC Madrid

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OPTOMECHANICAL DEVICES FOR MECHANOBIOLOGICAL FINGERPRINTING

By J. Tamayo, O Malvar, J.J. Ruz, S. García-López, M.L. Yubero, A. Cano, V. Puerto, A. Sanz, E. Gil-Santos, D. Ramos, A. San Paulo, P.M. Kosaka & M. Calleja

Instituto de Micro y Nanotecnología (IMN-CNM), CSIC, Tres Cantos, Madrid, Spain

E-mail: jtamayo@imm.cnm.csic.es

ABSTRACT:

Twenty years have passed since the first detection of biomolecular recognition using micromechanical systems[1]. In the last two decades, micro- nanomechanical systems have been refined to achieve amazing detection limits in force and mass that have enabled different schemes for ultrasensitive measurements of biological interactions as well as new ways of biological spectrometry. More recently, these figures of merit have been improved by coupling optical cavities to mechanical systems. In this talk, I will review the use of micro- nanomechanical systems for mechanobiological fingerprinting of biological entities, particularizing in the contributions of our group [2]. An essential core of this topic is the discussion about the mechanical coupling between a biological particle and a mechanical resonator, an issue that it is has been often oversimplified. We show that the biomechanical coupling that emerges between a bioparticle and a

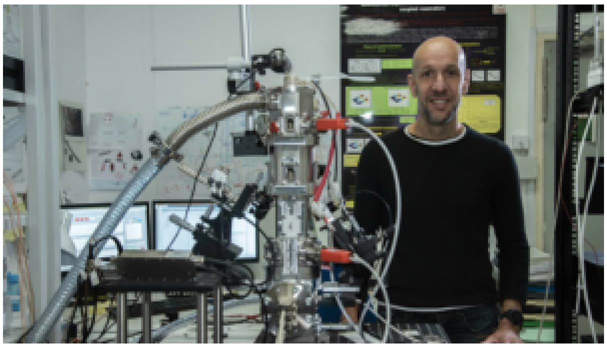
mechanical resonator is more complex than previously expect and it can give rise to different interaction regimes, in which the resonator response is dominated by different physical parameters of the analyte [3-4]. In particular, we will show experiments done with a variety of micro- nano- optomechanical systems using different measurement schemes where the mass, the stiffness and even the vibration modes of single biological entities can be measured with high sensitivity. It is now widely appreciated the essential role of mechanics in relevant biological processes and how disease can be revealed as changes in the mechanical properties of biological matter. I am pretty sure that future developments in optomechanical devices will contribute for major understanding of diseases as well as for new avenues in diagnosis and therapy.

[1] Fritz, J., et al. Translating biomolecular recognition into nanomechanics. *Science* **288,** 316 (2000).

[2] Kosaka, P. M., Calleja, M. & Tamayo, J. Optomechanical devices for deep plasma cancer proteomics. *Seminars in cancer biology* **52,** 26 (2018).

[3] Gil-Santos, E. *et al.* Optomechanical detection of vibration modes of a single bacterium. *Nature Nanotechnology* **15**, 469 (2020).

[4]Malvar, O. *et al.* Mass and stiffness spectrometry of nanoparticles and whole intact bacteria by multimode nanomechanical resonators. *Nature communications* **7**, 13452 (2016).



BIO:

Javier Tamayo received his PhD in Physics from the University Complutense of Madrid (1995-1998). He then moved to Bristol University to work on the mechanical properties of human chromosomes using atomic force microscopy to enlarge his vision about the link between mechanics and biology. He is now Professor in the Research Spanish Council and leads the Bionanomechanics Lab (http://www.imm-cnm.csic.es/bionano/en). The goal of the group is to provide answers and solutions to biological problems that are relevant for health by harnessing the intimate link between biological process and mechanical parameters. A central core in this research is the development of cutting-edge technologies and novel theoretical paradigms based on optomechanical devices and nanomechanical systems. His research has given rise to more than 100 highly cited publications. In recent years, the group has developed optomechanoplasmonic immunoassays with unparalleled limit of detection that are currently applied for the quest of cancer biomarkers for early cancer detection. In addition, the group has developed a novel optomechanical spectrometer able to identify individual pathogens by mechanical parameters. He also has recently focused his effort on disentangling mechanical effects in cancer initiation and progression by using a combo of optical and mechanical technologies. This research has revealed a new link between metabolism and mechanical properties in breast cancer cells. He is cofounder of two spin-off companies MecWins SL y Nanodreams, with the goal of implementing the group achievements in the healthcare system.