Simultaneous optical and mechanical sensing based on nano-optomechanical disks

Elena Sentre-Arribas[1], Eduardo Gil-Santos[1], Ivan Favero[2], Aristide Lemaître[3], Montserrat Calleja[1], Javier Tamayo[1]

[1]Bionanomechanics Lab, Instituto de Micro y Nanotecnología, IMN-CNM (CSIC), Isaac Newton 8 (PTM), E-28760 Tres Cantos, Madrid, Spain.
[2]Matériaux et Phénomènes Quantiques, Université de Paris, CNRS, 10 rue Alice Domon et Léonie Duquet, 75013 Paris, France.
[3]Centre de Nanosciences et Nanotechnologies, CNRS, Université Paris-Saclay, 10 boulevard Thomas Gobert, 91120 Palaiseau, France.

e.sentre.arribas@csic.es

A variety of optical and mechanical resonators have been successfully employed in a diversity of sensing applications. Optical resonators stand out for being extraordinary sensitive, while mechanical resonators are highly reliable. In this sense, optomechanical devices are unique platforms, since they simultaneously support high quality optical and mechanical modes. Here we prove that bringing together optical and mechanical resonances in a unique sensing platform, significantly improves the sensor assets, together with its reliability and robustness. In particular, we apply nano-optomechanical disks, which have already shown excellent capabilities when operating in liquids and for biosensing applications [1, 2]. We first apply them for monitoring environmental changes. Notably, the dual sensing approach allows decoupling relative humidity and temperature changes, reaching extraordinary precision, 0.01 % and 100 μK respectivelly. To further prove the capabilities of this novel method, we employ it for detecting individual bacteria (Figure 1). The technique allows to simultaneously access the bacterium optical and mechanical properties, accesing to its mass, rigidity, viscosity, refractive index and absorption coefficient [3].

References

[1] E. Gil-Santos, et. al. "High-frequency nano-optomechanical disk resonators in liquids". Nature Nanotechnology, 10 (2015) 810.
[2] E. Gil-Santos, et. al. "Optomechanical detection of low-frequency phonon modes of single bacterium". Nature Nanotechnology, 15 (2020) 469.
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Figures

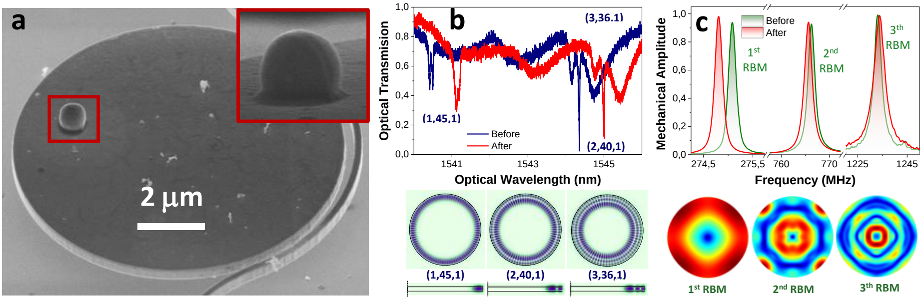

Figure 1. a. Scanning electron microscopy (SEM) image of a nano-optomechanical disks (5 μm in radius, 320 nm in thickness) with an adsorbed *Staphylacoccus Epidermidis* bacterium. The inset shows a zoom of the bacterium. **b.** Optical spectra of the nano-optomechanical disk before (blue) and after (red) the adsorption of the bacterium. Each deep corresponds to a particular whispering gallery mode (WGM) labeled by the interger numbers (p,m,l). The images bellow show the simulated electric field distribution associated to each WGM. **c.** Mechanical spectra of the nano-optomechanical disk before and after the adsorption of the bacterium, showing three resonances corresponding to the first three radial breathing modes (RBM). The images bellow show the simulated displacement field associated to each RBM.