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# Nanomechanical biosensors

Abstract:

Medical analysis for prognostic and treatment follow up is evolving toward real-time, bed size, protein finger print and personalized medicine. Therefore the molecular sensors used to detect and quantify the molecular tergt of interest should be fast, to operate in real time, selective, to be insensitive to the so-called biological noise and detect the lowest analyte concentration and multiplexed to provide a comprehensive description of the overall biological activity of the patient.
Micro and nanomechanical sensors (NEMS) represent a promising new class of biosensors that may respond the requirements listed above. Because of their extreme sensitivity, fast response, low cost, and multiplicity they can be competitive in terms of analysis time and costs, compared with current diagnostic systems (i.e. ELISA test ). The most common dynamic NEMS sensors, based on resonance frequency perturbation, are quartz microbalences, ring resonators and cantilevers. However, there a major limitation that need to be addressed: NEMS sensors, when operated in liquid, i.e. biological, environment, loose most of their extraordinary properties. As an evolution of cantilevers, we developed micro-pillars, columnar resonators that offers three key advantages on the current NEMS approach.
a) they can be arranged in dense arrays of several hundred thousand sensors in a squared cm, thus offering a promising approach to multiplexing, i.e. the detection of a full pool of markers within the same chip. To this purpose a strategy for decorating each sensor with a different functionalization and a parallel read-out should be developed. We already developed simple optical read-out optical method based on CCD imaging and software image analysis which allows the recording of the resonance frequency of hundreds of pillars in parallel that can provide information on tens of antigen in parallel.
b) they can be fabricated in superhydrophobic arrangement. In this way only the top of the pillar is in contact with the analyte while the structure oscillates in air. In this way real time analysis can be performed directly immersed in the analyte solution, whitout deteriorating the quality factor of the resonator.
c) they can be integrated as active elements into monolithic optical waveguides. Hundreds of pillar can be coupled to a single waveguide, each one modulation the optical signal at a different frequency thus offering the opportunity of a self-aligned full-optical simple read-out design suitable for integration on a lab-on-a-chip disposable device.
With the full development of the pillar approach, personalized medicine and early diagnosis of the most freighting diseases will become a reality.

## Summary

Keywords:

Nanoelectromechanical systems (NEMS), Fingerprint assays, Real time analysis, Point of care (POC) analysis

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