A 3D Lab-on-Fiber microstructure for ultrasound detection

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The emerging Lab-on-Fiber (LOF) technology is allowing to add new functionalities to optical fibers by exploiting the integration of micro- and nano- structures and functional materials on their surface, thus leading to a new class of compact optical probes which find application especially in bio-medical field [1]. Different LOF probes can be integrated inside a single needle for medical use, paving the way for the new intriguing vision of the "hospital in the needle", a multifunctional compact tool able to perform biosensing, drug delivery, as well as transmission and detection of ultrasonic waves inside the human body [2]. Ultrasound waves are largely used in bio-medical field, especially for imaging, However, the acoustic waves attenuation in tissues prevents from the use of high working frequencies, making necessary *in-vivo* approaches for the applications requiring micrometric resolutions [3]. In this framework, here we propose a novel LOF 3D micro-structure for ultrasound detection made of a polymeric membrane sustained by six pillars, directly integrated above the tip of a standard single mode fiber (Figure 1a). Such a structure essentially works as a Fabry-Perot cavity [4, 5], providing an interference fringe in the fiber reflection spectrum, which shifts accordingly with the structure vibrations caused by the incident acoustic waves (Figure 1b). A preliminary numerical investigation, based on finite element method [6], demonstrated that by opportunely dimensioning the geometrical parameters involved, i.e. the membrane diameter (D) and thickness (t), as well as the pillars diameter (d) and height (h), it is possible to tune the working frequency range up to tens of MHz (Figure 1c), reaching sensitivities higher than the standard configurations proposed so far, given by a polymeric slab directly deposited above the fiber tip to form a Fabry-Perot cavity [3]. Interestingly, the investigated structure can be effectively realized by exploiting the Two-Photon polymerization technique directly applied to the optical fiber tip [7].

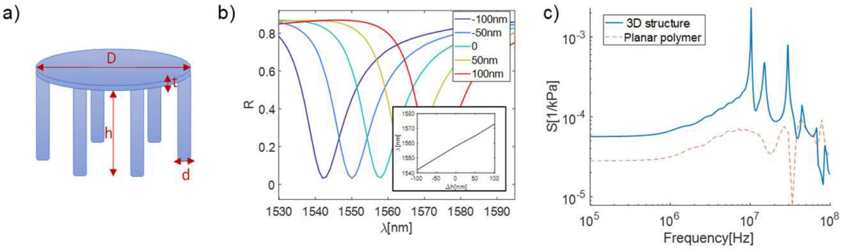

Figure 1. (a) Schematic representation of the studied structure. (b) Reflectivity spectra for different cavity length perturbations. (c) Sensitivity as a function of the incident wave frequency.

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