Optical microcavities for sensing applications

By Najwa Sidqi, PhD student at Helia-Photonics Ltd, Scotland

An optical microcavity, also called a microresonator, allows confinement of light in a small volume by resonant recirculation. The optical microcavity has a size dependent resonant frequency spectrum. At a microscale, the microcavity has resonant frequencies sparsely distributed throughout the spectrum. Ideally, the microcavity allows trapping of light indefinitely at precise resonant frequencies. The deviation from this ideal state is represented by the cavity Q factor. Due to the high potential of microcavities in many communication and sensing applications, the literature classifies microcavities based on the Q factor and the volume of the microcavity. Fabry-Perot resonator is a type of microcavities where the resonance feedback is accomplished using two mirrors as shown by the figure below. The Fabry-Perot microcavities are based on an ultra-high reflectance mirror technology. The upper and lower stacks are both Bragg mirrors constituted of alternating dielectric layers providing cavity confinement. Small volume ultrahigh-Q microcavities represent a growing interest in quantum information studies due to a strong coupling effect between the atom and the vacuum field [1].

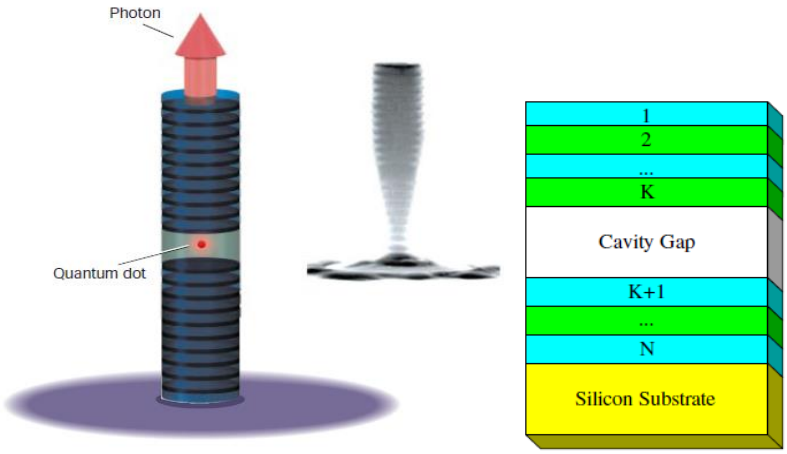

Figure 1: Scanning electron micrograph of a Fabry-Perot micropillar cavity [2] and a schematic diagram of a Fabry-Perot microcavity[3]

Fabry-Perot microcavities are widely used for sensing applications such as temperature and pressure sensing. This type of sensor detects the variation of the refractive index or the physical length change of the microcavity. The optimization of these sensors is mostly based on the nonlinearity error and the sensing resolution. High-reflectance mirrors are suitable for the sensing function but can induce sharp or small variations within the sensing ranging. In order to maximise the sensing range, it is very important to adjust the transmittance of the mirrors to the lowest value. Beside this main challenge, the performance of the microcavity can be restricted by mirror imperfections such as surface roughness, residual curvature of the surface or polishing defects. The control of the mirror quality, mirror imperfections and the evaluation of surface transmittance are going to be addressed by Helia Photonics.

References:

[1] Berman, P. R. (ed.) Cavity Quantum Electrodynamics(Academic Press, New York, 1993).

[2] Kerry J. Vahala, Optical microcavities, Nature, 2003, Vol.424(6950), p.839

[3] D G Guo, *Modelling and optimization of a Fabry-Perot microcavity for sensing applications*, Journal of Optics A: Pure and Applied Optics, 2004, Vol.6(11), pp.1027-1035