Integrated Fabry–Perot Cavities: A Quantum Leap in Technology

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Integrated Fabry–Perot cavities (IFPCs), often referred to as nanobeams due to their form factor and size, have profoundly modified the landscape of integrated photonics as a new building block for classical and quantum engineering. In this entry, the main properties of IFPCs will be summarized from the classical and quantum point of view. The classical will provide some of the main results obtained in the last decade, whereas the quantum point of view will exp

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In the quest for faster optical communication, researchers have been motivated to explore innovative optoelectronic devices. In the meantime, electronics circuits are approaching their limits in terms of bandwidth and power efficiency. For these reasons, keeping signals in the optical domain is seen as a possible strategy to overcome these limitations and continue to improve the high-performance computing (HPC) throughput and power efficiency. To achieve this, optical micro-cavities, which confine light in small volumes at optical wavelength scales, have emerged as important components for signal processing functions. Fabry–Perot cavities, from their inception [1] to the present day, have found many applications in telecoms, spectroscopy and sensing technologies [2][3]. The development of integrated optics in the last few decades has brought renewed interest in integrated Fabry–Perot cavities (IFPCs). High-Q optical microcavities, in particular, characterized by their high quality factor (Q) and their ability to confine light in small modal volumes (V_M), have been at the heart of recent advancements in optical telecommunication. They play a pivotal role in various signal processing functions [4], including channel-drop filtering, on–off switching and light modulation. Moreover, the exaltation of optical non-linearity and spontaneous emission inhibition or exaltation is primarily governed by the Q/V_M ratio. Thus, the quest for ultra-small high-Q cavities [5] has been critical in optical telecommunications [6] and in quantum optics [7]. Several strategies have been proposed to obtain high-Q cavities, like photonic crystals [8], micro-rings, micro-disks [9][10], micro-toroids [11], micro-spheres [12], meta-materials [13], plasmonics [14] and other interesting schemes [15]. However, each of these strategies either produces very large Q factors in excess of 10^6, but with rather large volumes, or, for the case of plasmonic resonators, a non-CMOS-compatible fabrication process. This entry will focus on arguably the most promising approach, Fabry–Perot cavities. It is believed that a Q factor as large as 10^8 can be achieved with cavities offering mode volumes close to the theoretical limit of $V_M = (\lambda/2n)3$, where λ is the resonant wavelength and n is the waveguide's refractive index.

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