1 Introduction

The number of sensor applications is steadily growing, and new application areas are opening as well, confirming that the ability to accurately sense physical, chemical, or biological parameters is of paramount importance for science, engineering, and biomedicine. In parallel, sensor technologies are improving in terms of accuracy, reliability, efficiency, robustness, miniaturization, and communications capability. The past years have shown how far sensor technology can progress; photonics has definitely largely contributed to these advances. Photonic sensors, indeed, offer fast, light, cheap, and small-footprint components and products, very often characterized by high functionality and low energy usage. Further advances can be expected due to the development of quantum photonics: quantum control over light–matter interactions would enable new classes of measurement and communications solutions that have not been possible so far.

Recently, significant achievements have been made possible by devices pertaining to the class of resonant whispering-gallery-mode (WGM) microcavities [or whispering-gallery-mode resonators (WGMRs)]. Dielectric 2-D microresonators with circular or quasi-circular (e.g., slightly elliptical) planar symmetry, and the corresponding 3-D devices with spherical (spheroidal) or cylindrical symmetry, support confined propagation modes, which possess outstanding properties: these devices simultaneously hold unprecedented potential for a wide range of applications and constitute a great platform with which to explore fundamental physics.[1] Current technology allows us to fabricate, in many different materials, microresonators with a small modal volume V (and therefore a high energy density), very high quality factor Q, and large free-spectral range (FSR). The geometries range from microrings and microdisks to capillaries, microspheres, microbottles, and microbubbles. These microresonators have already demonstrated their excellent characteristics not only in the field of sensing, and biosensing, in particular, but also in the areas of lasers, nonlinear optics, and quantum information processing.[1–4] The following are a few recent examples of the miniaturization and device performance achievable with the WGMR technological platform:

1. Ultra-small (<2 μm in diameter) microring and microdisk lasers with an asymmetric air/GaAs/$Al_{0.98}Ga_{0.02}As$ waveguide and an active region based on InAs/InGaAs/GaAs quantum dots emitting around 1.3 μm.[5]
2. A thermodynamical-noise-limited microlaser at 1.56 μm using the dual WGM super-cavity approach (with 2-mm-sized MgF_2 cavities), exhibiting a fractional frequency instability of 1.7×10^{-13} at a 0.1-s integration time, corresponding to a fundamentally thermal-noise-limited integral linewidth of 8.7 Hz.[6]
3. By using a 3-mm silica spherical resonator (FSR $\approx$ 22 GHz) for experimental comparison, closed-form expressions for the Raman self-frequency shift and the efficiency of dissipative Kerr cavity solitons have been derived, which should be applicable to predict soliton behavior in any microcavity system.[7]