Focus Issue: Physics and Applications of Microresonators

Introduction

Studies of microcavities date back to the beginning of the twentieth century, when the theory of Mie resonances was developed. For a long time it was primarily an area of applied optics dealing with the scattering and lasing properties of microparticles and microdroplets. In recent years, due to progress in photonic integrated technology, it has become possible to fabricate arrays of cavities in chip-scale structures with *Q* factors in excess of 100 million. New physics arises in such structures due to an unprecedented resonant energy build-up in the cavities, with an associated increase of radiative pressure so that purely electromagnetic properties become coupled to mechanical and thermodynamic properties of such systems. Extremely long dwelling times of photons in cavities make possible dynamic tuning of their frequencies on the scale of the photon lifetime. Cavities with *Q* factors ranging from thousands to millions are widely used in studies of cavity QED effects, excitonic and plasmonic strong coupling, resonantly enhanced nonlinearity, parametric oscillation, polaritonic and Raman lasing, configuration interaction and coherent propagation effects in coupled cavities, effects of localization and percolation of light in lattices of disordered cavities and many other interesting effects. An old subject of focusing of light by spherical and cylindrical cavities has been revisited recently, resulting in the development of a concept of "photonic nanojets". Ultra high *Q* factors in combination with extremely small modal volumes lead to a wealth of applications for microcavities in biochemical sensing with single molecule detection, developing sources of single photons, electromagnetic cooling, dynamical frequency tuning and switching, as well as in developing slow light structures, low threshold lasers and parametric oscillators.

In putting together this Focus Issue, an attempt was made to represent the fundamentals and the applications of microresonators from the point of view of physical effects in such systems. This Focus Issue reflects presentations at several meetings held in 2007, including Microresonator Sessions at Photonics West, ICTON, and a Gordon-type workshop organized by the editor of this Issue in Charlotte in June 2007. This issue starts off with the review by T. Kippenberg and K. Vahala, which addresses an emerging area of opto-mechanical coupling in microcavities. The invited papers are divided into four groups: (i) photonic crystal cavities, (ii) rings, disks and other cavities, (iii) novel concepts and theory, and (iv) sensors. The first two groups are based on using more mature semiconductor technology which in conjunction with modeling should deliver a broad variety of chip-scale photonic devices. The third group addresses novel optical and transport phenomena in single and multiple coupled cavities. Finally, the sensors group presents designs of structures aimed at ultrasensitive detection of biochemical binding events at the interfaces of the cavities and demonstrates practical results achieved in this area.

In conclusion, this Issue was created with the intent to represent the current state-of-the-art in technology, theory and applications of optical microcavities. It was also intended to create an international forum for microcavity work by incorporating under a single umbrella a broad range of research in this area spanning from photonics to material science and engineering.

I am very grateful to all invited authors for their effort in presenting high quality results in this area. My special thanks to Martijn de Sterke who strongly supported the idea of this Focus Issue and helped me with related editorial issues. I would like to thank Jennifer Mayfield, Meghan Ely, and Victoria Tesfamariam for the technical assistance with publishing this Focus Issue.

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