Semiconductors-based photonic crystal nanocavities and their composited systems

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Abstract

Photonic nanocavities with high quality (Q) factors and small modal volumes (V) of a few cubic wavelengths can significantly enhance the interaction between the material and incident photons. In particular, semiconductors-based photonic crystal nanocavities have developed rapidly thanks to the advanced nanofabrication technologies and general design rules to achieve large Q/V values. Recently, silicon (Si)-based photonic nanocavities with ultrahigh Q factors over one million have been demonstrated in two-dimensional (2-D) photonic crystal structures, which operate mainly in the optical telecommunication bands. These photonic crystal nanocavities can be coupled to electronic, optical, and mechanical systems, and exploited in the development of various related fields such as ultrasmall photonics, nonlinear optics, cavity quantum electrodynamics, and even optomechanics.

In this talk, the basic structure and characteristics of Si photonic crystal nanocavities will be presented. Furthermore, the recent progress and nonlinearity of the high-Q Si photonic crystal cavities are shown theoretically and experimentally. In particular, the optical characteristics of the composited systems of the photonic crystal nanocavities coupled to the artificially-introduced matters (dielectrics and metals) will be presented. An important design rule that the index-symmetric distribution of the introduced dielectrics is a critical factor to realize ultrahigh Q factors for dielectric-embedded 2-D photonic crystal structures will be shown, which is very useful in addressing the current issues of their heterogeneous integration, heat management, and even sustainability of optical characteristics in 2-D photonic crystals. Also, it is shown that optical properties of the composited system of the photonic crystal nanocavities coupled to the introduced metals can be controlled easily. Lastly, superior characteristics of SiC-based photonic crystals nanocavities to those of Si photonic crystals will be presented. Even though Si is known as one of the hardest materials and as a wide band gap semiconductor, it has been not revealed how SiC photonics would perform compared to conventional photonics. The theoretical and experimental results that SiC-based photonic crystal nanocavities indeed exhibit advantageous characteristics in the field of semiconductors-based nanophotonics will be presented.

Related references:

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