Photonic Crystal with Quantum Dots and/or Micro Electro-Mechanical Systems for Advanced Nanophotonic Devices

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Since the first proposal of the quantum dots (QDs) for the three dimensional quantum confinement of carries in 1982 by Arakawa *et al.* [1], various efforts have been devoted to the realization of nanophotonic devices with the QDs, including lasers, detectors, and optical amplifiers[2]. In these devices, device performance is enhanced through the change of density of states and volume effects. The control of the number of QDs and size uniformity is crucial for realizing such high performance. In addition, the QDs are useful for single photon light sources which are applied to quantum cryptography communication systems. On the other hand, photonic crystals (PhCs) [3] are now promising to obtain higher performances of such advanced nanophotonic devices through enhanced interaction between photons and electrons and/or controlled photon modes. Combination of PhCs and QDs is now indispensable for future nanophotonic devices.

Optical switches and tunable PhC devices are promising devices for future photonic node devices. These functional PhCs are already proposed by utilizing electro-optic, thermal and nonlinear optical effects through the change in refractive index of material itself. However, it is not easy to realize such devices. The combination of PhC with micro electro-mechanical systems (MEMS) can provides another promising way for realizing such functional PhCs. We have proposed MEMS-integrated PhC devices for high-efficiency functional PhC devices[4]. In such devices, mechanical tuning of the device performance/ functions with relatively small operating voltage low operating energy can be achieved.

In this paper, we discuss the impact to combine the concept of the electronic nanostructures (i.e., QDs) and the photonic nanostructures (i.e., PhCs) for future high performance nanophotonic devices with emphasis on application to light sources. The control of photons using the PhCs with the MEMS is also discussed by showing numerical calculations and an experimental demonstration of switching operation in a PhC line-defect waveguide with the MEMS.

References

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