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Dispersion peculiarities of exciton-like electromagnetic excitation in disordered lattice of coupled microresonators

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Photonic structures and metamaterials are in the focus of theoretical and experimental interdisciplinary studies, which span laser physics, condensed matter physics, nanotechnology, chemistry and information science. The physics of photonic super crystals is in many ways similar to the physics of crystalline solids. Due to imperfections of the super crystal lattice photonic gaps may contain impurity states, which are of crucial importance in realistic photonic structures. While the theory of impurity bands and excitons in semiconductor crystals has been developed in 1970-1980s, a similar theory for photonic crystals is yet to be constructed. In this work we carry out a theoretical study of exciton-like electromagnetic excitations in disordered photonic super crystals composed by coupled microcavities. Here we study dispersions of localized electromagnetic excitations in an array of coupled microcavities which form a non-ideal super crystal rich by point-like defects. We study the propagation peculiarities of these excitations in a two-dimensional non-ideal binary micro-cavity lattice with the use of the virtual crystal approximation. The effect of point defects (vacancies) on the excitation spectrum is being numerically modeled. The adopted approach permits to obtain the dispersion law and the energy gap width of the considered quasiparticles and to analyze the dependence of their density of states on defect concentrations in a microcavity super crystal. Our study contributes to the modeling of novel functional materials with the controllable propagation of electromagnetic excitations.

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Laser from optically pumped quantum dot CdSe/ZnS

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A number of reports have been published on laser from quantum dot nano structure by current injection. In contrast, we have recently obtained amplified spontaneous emission (ASE) and laser from CdSe/ZnS quantum dot (QDs) in a colloidal liquid. A Third harmonic of Nd: YAG laser (355nm) was used to produce laser-induced fluorescence (LIF) at 605 nm with a spectral width of 20 nm [full width at half maximum (FWHM)]. When the pump pulse energy went up to 20mJ and focusing were carefully optimized, an ASE at 610 nm with a spectral width of $\Delta\lambda = 8$ nm (FWHM) could be obtained. The beam was directional with a divergence of 10 milli radians (mrad); but the conversion efficiency was about 0.05%. This is perhaps one of the very few reports on laser from nano structures. It is important to draw attention to the following facts: (a) ASE could not be obtained by transverse excitation as in the case of conventional laser dyes such as fluorescein or coumarin or more recent conjugated polymers MEH_PPV. (b) Optical gain of the QDs appears to be quite inferior to conventional to conventional laser dyes like RB or conjugated polymer like MEH-PPV, though the quantum yield of fluorescence are comparable. This is because QDs do not go into solution in any of the solvents; they remain only as suspensions, with a strong tendency to go to precipitation after a certain level of concentrations. Because of this, most of the photons incident upon the QD get scattered; only a small number of them get absorbed and re-emitted as fluorescence, albeit efficiently. In order to improve the lasing characteristic of QD, one may need to do energy transfer process (like He – Ne or N2 CO2 laser). For example, coumarin dye laser pumped by the same frequency tripled Nd:YAG could provide better laser efficiency. More importantly new techniques of dissolving high concentrations of the QD in suitable liquid are being tried by other group. Nevertheless, it appears that the optically pumped QD laser would not be comparable to RB or MEH-PPV laser in terms of efficiency.

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