Effects of the strong coupling between light and excitons in stabs of the PbI_4-based layered perovskite-type semiconductors

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The optical properties of resonant (radiative) polaritons in single and multiple two-dimensional excitonic systems were studied in a number of papers both theoretically [1-6] and experimentally [7-10]. The vast majority of these studies were devoted to the GaAs/AlGaAs quantum-well (QW) structures. Recently, [11-15] a strong exciton-photon coupling in the PbI_4-based layered perovskite-type semiconductors was observed and theoretically studied. The longitudinal-transverse (LT) splitting of excitons in these materials is two orders of magnitude greater than that in GaAs QW structures. In this paper the polaritonic effects in a slab of material with strong coupling between the excitons and light are theoretically studied. Because the exciton Bohr radius in the PbI_4-based layered semiconductors is of the order of ten Angström units, we can describe the response of the excitonic system by a local dielectric susceptibility. The full system of the Maxwell equations is solved in each medium with applying conventional boundary conditions of continuity of tangential component of the electric and magnetic fields at the slab surfaces. As a result, we obtain the dispersion of every radiative exciton-polariton mode (L, T and Z modes) and calculate the transmission/reflection and absorption spectra of light incident onto the slab at arbitrary angle to the slab-surface normal. The strong coupling between the light and excitons, which is fully accounted for in our theoretical approach with no small parameter in use, leads to a number of new pronounced effects. In what follows we list some of those effects. In the case of symmetric dielectric environment of the excitonic slab, a strong renormalization of the frequency of T and Z radiative modes takes place in the vicinity of the light cone on the dispersion plane. In the case of asymmetric dielectric environment, a strong renormalization of the frequency of T and Z modes takes place in the whole region of the dispersion plane between the two light lines corresponding to different media surrounding the excitonic slab. Strongly inhomogeneous electromagnetic wave (which can be also represented by the wavepacket over the plane homogeneous waves) is emitted from the excitonic slab at oblique (grazing in the case of symmetric environment) angles in respect to the plane of the excitonic slab. The renormalization of exciton-polariton frequencies on the dispersion plane corresponds to strong angular dependence of the emission frequency. The absorption resonances arisen due to excitation of T and Z modes by incoming light exhibit appreciable frequency shift in the attenuated total reflection regime. Higher polaritonic modes may show up in the absorption spectra in the frequency range around the excitonic pole of the dielectric function in highly ordered slabs. It should be noted that all these effects are expected to be unnoticeably weak in GaAs QW structures in consequence of the small LT splitting in those structures as compared to that in the PbI_4-based layered semiconductors.

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