Excitonic polaritons in semiconductor solid solutions $Al_xGa_{1-x}As$

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The band-edge spectra and excitonic absorption coefficient integrated over photon energy were measured for semiconductor solid solutions $Al_xGa_{1-x}As$ with large concentrations ($x = 0.15$ and 0.21). For the ground-state exciton the temperature dependence of integral absorption was established to possess the features typical of exciton-polaritons propagation in a quasi-homogeneous semiconductor with spatial dispersion.

The experiments were performed in the temperature range 1.7 to 380 K for high-quality $Al_xGa_{1-x}As$ unsupported samples with thickness of 3 to 7 μm grown by MBE. Inhomogeneously broadened 1*s*- and 2*s*-exciton lines were observed below the band-edge of the solid solutions, and the concentration-dependent exciton parameters were found. The true width of the 1*s*-exciton line was found to be as small as 2.6 meV ($T = 1.7$ K), the value being consistent with theoretical estimations and the best data on luminescence. Although inhomogeneous broadening of exciton lines associated with exciton potential fluctuations provides dominating contribution to the observed exciton linewidth at T=1.7 - 60 K, it does not influence the temperature-dependent integral absorption $K(T)$. The integral absorption coefficient $K(T)$ of $Al_{0.15}Ga_{0.85}As$ sample was found to grow monotonously with increasing temperature up to its critical value $T_c = 155$ K and then to saturate on the level of K_{max}= 89.5 eV/cm. Qualitatively, such temperature dependence $K(T)$ is typical of exciton-polaritonic energy transfer in the presence of excitonic spatial dispersion, the effect being earlier observed only for semiconductor crystals (e.g., [1] for GaAs crystals).

Taking into account high homogeneity of the samples $Al_xGa_{1-x}As$ under study, we interpreted the experimental results on the integral absorption within a theory of light propagation developed for homogeneous media with spatial dispersion. It predicts existence of two transverse exciton and polariton waves whose refraction indices (contributions to absorptivity) strongly depend on the exciton damping rate (on temperature in an experiment). The tempetature dependence of the integral absorption $K(T)$ consisting of growth and saturation regions is interpreted as a result of competition between these modes, the variation of integral absorption being associated with the excitonic spatial dispersion. At the critical value of the exciton damping rate (temperature T_c) the transition in the integral absorption occurs to "classic" temperature-independent regime typical of one-mode exciton-polariton electromagnetic transfer because the spatial dispersion effects disappear above T_c. In this work, having observed the critical temperature dependence of integral absorption for solid solutions of high homogeneity quality, we applied the above theoretical argumentation to the disordered solids in which fluctuating excitonic potential was assumed to be weak (quasi-homogeneous medium). To summarize, after [1] we have used the observed critical temperature behavior of integral absorption to argue the existence of propagating exciton-polaritons in high-quality solid solutions $Al_xGa_{1-x}As$ with quite large concentrations of substitution component up to $x \approx 0.2$.

[1] V.A. Kosobukin, R.P. Seisyan, S.A. Vaganov. Exciton-polariton light absorption in bulk GaAs and semiconductor superlattices. Semicond. Sci. Technol. 1993, **8** (7), 1235-1238.