EXCITON RELAXATION AND SPIN DYNAMICS IN $Al_xGa_{1-x}As$ FILMS

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We have studied the energy relaxation and spin dynamics of bulk excitons in a series of high quality $Al_xGa_{1-x}As$ epilayers as a function of the excitation power density. We have found an anomalous behavior of the formation time of free excitons after non-resonant excitation for low power densities. This anomaly is tentatively attributed to the excitonic capture on localized states. The spin polarization decay time is one order of magnitude longer than in quantum wells and displays a weak dependence on excitation density. The increase of the Aluminum content in the alloy accelerates slightly the dynamics.

We have investigated five high purity $Al_xGa_{1-x}As$ films, with Aluminum content $0 \leq x \leq 0.09$, grown by Molecular Beam Epitaxy [1]. The samples are non-resonantly excited with 2 ps long pulses and kept at low temperature (5 K) in a cold finger cryostat. The photoluminescence is spectrally-resolved using a 60 cm spectrograph and time-resolved with a streak camera, the overall time resolution being 50 ps. To gain access to the spin degree of freedom we use a combination of $\lambda/4$ plates and linear polarizers to analyze the PL into its σ^+ and σ^- components.

We have found rather long recombination times together with very narrow emission line widths, which assure the excellent quality of the samples. We have extracted from the time evolution traces the formation (t_F) and recombination (t_D) times of free excitons (FX) with center of mass momentum $K \sim 0$. We have found that t_F increases with excitation power until ~ 3 mW and then decreases with a further increase of power. A similar behavior has been described in quantum wells and bulk samples and attributed to the competition of two different FX formation mechanisms, geminate and bimolecular [2]. Here we will consider an alternative approach which takes into account the competition of trapping of FX by localized states and exciton-exciton scattering. The former process will dominate the dynamics under low excitation while the latter will govern the high excitation density regime [3]. t_D monotonically increases with excitation power, in agreement with the two competing mechanisms considered. The maximum of the polarization degree (at $t = 0$) monotonically decreases with excitation power due to the enhancement of exciton-exciton scattering, which yields to a rapid spin relaxation. The spin flip time, extracted from an exponential decay of the time evolution of the polarization degree, decreases from ~ 500 ps to ~ 100 ps with increasing excitation density. We have investigated the effect of alloy scattering on the exciton dynamics by studying different samples with increasing Aluminum content. We have found that all the characteristic times, exciton formation, recombination and spin flip times show a weak shortening with increasing the Aluminum concentration.

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