Spin coherence of electrons and holes in ZnSe-based quantum wells

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Coherent spin dynamics of electrons and holes have been studied by a picosecond pump-probe Kerr rotation technique in ZnSe-based quantum well (QW) structures with a binary material of QW. Samples with low-density two-dimensional electron and hole gas have been chosen. Long-living spin coherence both of holes (≈1ns) and electrons (up to 32 ns) was observed at low temperatures of 1.8 K when the resident carriers are localized well width fluctuations. Two sets of samples were have been examined: (1) structures with ZnSe/$Zn_{0.82}Be_{0.08}Mg_{0.10}Se$ single QW (thickness varying from 7 to 19 nm) surrounded by an additional $Zn_{0.71}Be_{0.11}Mg_{0.18}Se$ barriers were nominally undoped having concentration of resident electrons (2DEG) of $5x10^9 cm^{-2}$; (2) structure containing ZnSe/$Zn_{0.89}Mg_{0.11}S_{0.18}Se_{0.82}$ single QW with concentration of two dimensional hole gas (2DHG) of $3x10^{10}$ cm^{-2}.

The time-resolved pump-probe Kerr rotation technique with selective excitation of the trion or exciton states was used. Experiments were performed in magnetic fields 0–5 T applied in the plane of the structure (the Voigt geometry). The sample temperature was tuned in a range 1.8–270 K. The long-lived electron spin beats with dephasing time up to 32 ns have been observed in the structure with 2DEG under resonant trion excitation. In case of the resonant excitation of the exciton (detection at trion resonance) the maximum dephasing time was 21 ns. The electron spin beats were visible up to room temperature. The spin dephasing rate increases linearly with temperature in the temperature range 10 - 170K. It means that Dyakonov-Perel spin relaxation mechanism on k-linear spin splitting of the conduction band dominates for these temperatures. The observed decrease of the zero-field peak in the signal of the resonant spin amplification relatively to the other peaks we assign to the anisotropic spin relaxation of electrons at high levels of excitation.

The long-lived hole spin beats with dephasing time ≈1ns (T=1.8K and B=0.5T) have observed in the structure with 2DHG. The electron spin beats with fast spin relaxation time ≈10 ps have observed simultaneously with hole spin beats at magnetic field B≈3T. An additional above-barrier illumination leads to appearance of long-lived electron spin beats, while the amplitude of the hole beats was decreasing.