MAR12-2011-002882

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

3D Electron Spin Relaxation Control by Electric Field in Quantum Wells

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We have measured the electron spin relaxation time in (111)-oriented GaAs quantum wells by time-resolved photoluminescence. By embedding the QWs in a PIN or NIP structure we demonstrate the tuning of the conduction band spin splitting and hence the spin relaxation time with an applied external electric field applied along the growth z direction . The application of an external electric field of 50 kV/cm yields a two-order of magnitude increase of the spin relaxation time which can reach values larger than 30 ns; this is a consequence of the electric field tuning of the spin-orbit conduction band splitting which can almost vanish when the Rashba term compensates exactly the Dresselhaus one [1]. The spin quantum beats measurements under transverse magnetic field prove that the D'Yakonov-Perel (DP) spin relaxation time is not only increased for the Sz electron spin component but also for both Sx and Sy. These results contrast drastically with the (001) and (110) quantum wells.The role of the cubic Dresselhaus terms on the spin relaxation anisotropy will finally be discussed. The tuning or suppression of the DP electron spin relaxation demonstrated here for GaAs/AlGaAs quantum wells grown on (111) substrates is also possible in many other III-V and II-VI zinc-blende nanostructures since the principle relies only on symmetry considerations.

[1] A. Balocchi, Q. H. Duong, P. Renucci, B. L. Liu, C. Fontaine, T. Amand, D. Lagarde, and X. Marie, Phys. Rev. Lett 107, 136604(2011)

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