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Effect of strain on the spin splitting of holes in GaAs/GaAlAs quantum wells

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The Zeeman splitting of holes in the ground valence subband of a strained GaAs quantum well is studied theoretically. We consider heterostructures grown on differently oriented substrates and subjected to a uniaxial stress along the growth direction. The g factor of confined hole states is obtained under a magnetic field directed parallel to the well plane. Calculations are performed in the framework of the Luttinger model, including the effects of bulk inversion asymmetry. The wave-vector and magnetic-field dependences of the spin splitting are fully taken into account. The g factor is evaluated numerically using the finite-difference method. We show that the spin splitting of the states close to the ground subband edge remains almost unchanged upon uniaxial tension, but increases rapidly with the compressive strain, as shown in Fig. 1. The increase of g factor occurs in structures with different orientations and is related to the strain-driven transition of the topmost subband from heavy-hole to light-hole type. For low-symmetry growth directions, applying a strain also modifies the anisotropy of the hole spin. We show that the high anisotropy of spin splitting, observed in the unstrained [113] wells [1], disappears under a compressive strain. In contrast, the spin splitting in the [110] wells, almost isotropic in the zero-strain case, becomes extremely anisotropic under small uniaxial compression. The anisotropy results from the strain-induced anticrossing of the topmost valence subbands and corresponds to the pinning of hole spin to the [11$\underline{2}$] axis [2]. We discuss the wave-vector dependence of the Zeeman splitting both in the limit of low and high magnetic fields.

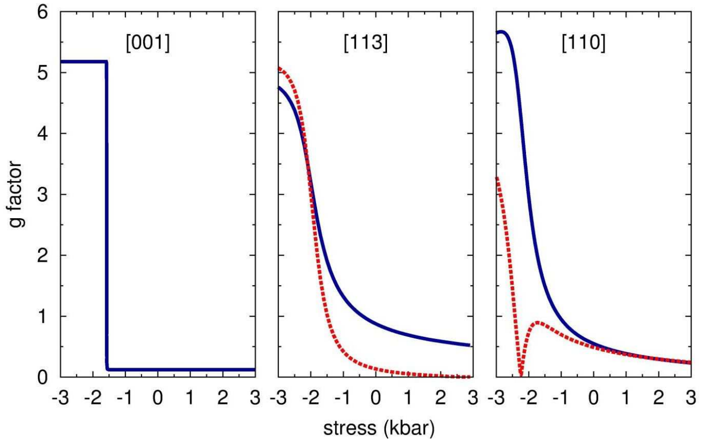

Fig. 1. Stress dependence of the g factor in 15-nm quantum wells with growth directions [mmn] = [001], [113], and [110], calculated at the subband edge (k = 0) for **B**||[nn($\underline{2m}$)] (solid lines) and **B**||[$\underline{1}$10] (dotted lines). The spin splitting in the [001] wells is isotropic.

[1] R. Winkler et al., Phys. Rev. Lett. **85**, 4574 (2000).
[2] M. Kubisa et al., Phys. Rev. B **83**, 195324 (2011).