Light hole excitons in (Cd,Mn)Te/(Cd,Mg)Te core/shell nanowires

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Spins of holes confined inside semiconductor nanostructures are promising candidates for applications in solid state based quantum technologies because of a quite weak hyperfine coupling to the nuclear spin bath resulting in a significant reduction of the decoherence as compared to electron spins [1]. Most of the studies performed up to date are dedicated to the properties of heavy hole spins, since the heavy holes are usually the ground state of optical transitions in semiconductor nanostructures. This is due to the fact that the spatial confinement and strain present in quantum wells and quantum dots favors usually the heavy hole character of the optical transitions. Light hole excitonic emission from individual nanostructures is much less explored. In two quite recent publications, the light hole excitonic emission is reported in tensely strained quantum dots [2] and in nanowire quantum dots [3].

In this work, we report on the growth of (Cd,Mn)Te/(Cd,Mg)Te core/shell nanowires by molecular beam epitaxy using the vapor-liquid-solid growth mode. In the nanowire core/shell geometry, the compressive strain acting on the nanowire core should lift the degeneracy of the light and heavy hole bands and shift the light hole band in a way that it becomes the ground state. The presence of a small percentage of magnetic Mn-ions in the nanowire cores increases significantly the Zeeman splitting of the excitonic emission due to *sp-d* exchange interaction between Mn-ions and band carriers, which enhances any spin-related effects in an external magnetic field and enables the present study.

A detailed magneto-photoluminescence investigation has been performed on several individual (Cd,Mn)Te/(Cd,Mg)Te core/shell nanowires and demonstrates the light hole excitonic character of the emission from all investigated structures. The measurements are performed at low temperatures in a geometry, when the light propagation direction is perpendicular to the nanowire axis. The magnetic field is applied in Voigt configuration, so that it can be applied either along or perpendicular to the nanowire axis. Most importantly, we demonstrate that the value of the spin splitting depends strongly on the direction of the applied magnetic field with respect to the nanowire axis. The smallest spin splitting is observed for the magnetic field applied along the nanowire axis and the largest for the perpendicular magnetic field.

The latter effect is attributed directly to the strain induced light and heavy hole level splitting with the anisotropy axis corresponding to the nanowire axis. The fact that the largest spin splitting is observed for the magnetic field direction perpendicular to the nanowire axis demonstrates clearly the light hole excitonic character of the optical emission. The values of the light and heavy hole splitting are determined for more than 10 nanowires from the fit of the experimental data to the calculated theoretical model.. They vary from 7 meV to 20 meV depending on the particular nanowire suggesting different strains.

References:

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