Magneto-optical anisotropy of ZnMnTe/ZnMgTe core/shell nanowires

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Incorporation of transition metal ions into semiconductor nanowires affects considerably spin-related properties of carriers confined inside of these structures. In particular, giant Zeeman splitting of excitonic levels due to strong sp-d exchange interaction between band carriers and magnetic ions has recently been observed in these structures [1,2]. The unique character of nanowires with respect to other nanostructures relies on their strongly uniaxial shape which could result in some unique properties, such as, e.g., magnetic anisotropy.

In this work, we show that the value of the giant Zeeman splitting depends strongly on the direction of the applied magnetic field with respect to the growth axis of the nanowire. ZnMnTe/ZnMgTe core/shell nanowires with Mn content of about 5% in the cores are dispersed randomly on Si substrate. Individual nanowires are addressed by means of microphotoluminescence, whereas the growth axis direction of the particular nanowire under investigation is determined by measuring the linear polarization anisotropy of its emission. Magnetic fields up to 2 T can be applied in any direction in the plane of the sample. It is important to note that in our configuration the magnetic field is applied always in the Voigt geometry, i.e., light propagates perpendicularly to the direction of magnetic field. The energy shift of the emission line reflects directly the value of the giant Zeeman splitting of excitonic levels inside the nanowire. The most important result is that while applying the magnetic field along the axis of the nanowire, the value of the giant Zeeman splitting is up to 5 times larger than in the case of the perpendicular magnetic field.

In order to confirm that the nanowire geometry is crucial for the observed anisotropy of the giant Zeeman splitting, a magnetic field with a constant value of 2 T is applied systematically at various angles with respect to the nanowire axis in the plane of the sample. Indeed, a strong dependence of the emission line spectral position on the magnetic field direction is observed. The largest energy shift of 20 meV is observed for the directions along the axis of the nanowire and the smallest shift of 4 meV for the magnetic field for the directions perpendicular to its axis, which confirms the predominant role of the nanowire shape for the observed effect.

Two possible interpretations of these results are discussed. The first relies on the anisotropy of excitons inside the nanowire, caused by the light and heavy hole splitting, which could arise either from the strain originating from the lattice mismatch between the core and shell semiconductor, or from the uniaxial quantum confinement of the nanowire. The second possible interpretation bases on the magnetic anisotropy inside the nanowire.

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