Growth of optically active diluted magnetic ZnMnTe/ZnMgTe core/shell nanowires

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This presentation is devoted to the growth of optically active ZnMnTe nanowires by molecular beam epitaxy (MBE) which enables the study of giant magnetooptical effects in nanowire heterostructures. The main difficulty which had to be overcome was related to the initial absence of any near band edge emission from MBE grown ZnTe [1] and ZnMnTe [2] nanowires, despite of excellent crystallographic properties of these structures.

Recently, we have found that the presence of a shell made of a semiconductor with a relatively large energy gap e.g. ZnMgTe for ZnTe nanowires, results in the activation of a strong emission in the near band edge energy region. This finding points surface states to be responsible for the initial absence of this emission, whereas the presence of the shell pushes away the surface from the central part of the nanowire. After optimizing growth parameters such as: thickness of the shell, its deposition temperature, Mg composition, the ZnMgTe shell is added also for ZnMnTe nanowires.

To be more precise, ZnMnTe nanowires with various Mn contents up to 6% are grown by molecular beam epitaxy by employing the vapor-liquid-solid growth mechanism induced by gold catalysts. After the growth of 1.5 μm long ZnMnTe nanowires at 400°C, the growth temperature is considerably reduced to 250°C - 300°C for the deposition of the ZnMgTe shell. At such a low temperature the growth occurs mostly in the radial direction of the nanowire and results in an average ZnMgTe shell thickness of 18 nm (29 nm) after 10 min (15 min) deposition.

Photoluminescence measurements performed at low temperature (3 K) show clearly that the presence of Mn ions in ZnMnTe nanowires results in the blue shift of the near band edge emission peak, which corresponds to the increase of the energy gap of ZnMnTe with increasing Mn content. This effect confirms the successful introduction of Mn ions into crystallographic structure of nanowires. Moreover, after applying an external magnetic field up to 9 T, this emission exhibit a giant red shift of about 40 meV in case of the sample with the highest average Mn content. The dependence of the spectral position as a function of the magnetic field can be well fitted with a Brillouin function which clearly demonstrates that the origin of this energy shift is the sp-d exchange interaction between Mn-ions and band carriers.

Particularly interesting is the polarization behavior of the near band edge emission. The degree of the circular polarization increases with increasing magnetic field, as expected from selection rules for optical transitions. It reaches its maximum already at 2T, but in contrast to the emission from bulk crystals or diluted magnetic quantum dots [3] the line exhibit maximal circular polarization of only 40%, and not 100%. This may be explained by the particular property of the emission from nanowires, which is, as already well established, linearly polarized without magnetic field due to large contrast of dielectric constants between the nanowire material and the surrounding. This initial linear polarization influences the circular polarization of the emission at magnetic field.

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