Selected physical properties of auto-catalytic GaAs:Mn nanowires grown by molecular beam epitaxy on silicon substrates

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GaAs nanowires (NWs) are attractive for potential applications in nanodevices, since they are built from a material which is widely used in optoelectronics. For functional devices the control over the polarity and concentration of charge carriers, i.e., doping of the given semiconducting materials is essential. However, since the growth of the NWs is governed by principles different from the case of bulk crystal or thin film growth, the doping mechanisms of a NW are still not fully recognized. Particularly interesting is doping GaAs NWs with Mn. In GaAs the Mn^{2+} ions occupying Ga sites and provides both magnetic moments, due to the spin polarisation of the half filled 3d shell, and acts as an effective acceptor, what opens possibility of using Mn-doped GaAs NWs for studying interesting phenomena associated with interactions between charge carriers or photons with localized, single Mn spins.

In this work we report on the results of our studies concerning the GaAs:Mn NWs. The NWs were grown in self-catalytic growth mode on oxidized Si(100) surface by MBE and characterized by SEM, TEM, PL, CL, Raman scattering and electron transport measurements. In order to analyze the influence of Mn presence on the physical properties of NWs the undoped GaAs NWs obtained in otherwise exactly the same manner as those containing Mn were also investigated. The results of resistivity measurements as a function of temperature showed that contrary to undoped GaAs NWs the Mn doped ones are conductive. The dependence of the I-V characteristics on the voltage applied to the substrate back gate revealed the p-type conductivity, confirming the acceptor character of Mn impurities embedded into NW. This finding is in agreement with the results of PL and CL measurements, which confirmed the presence of Mn^{2+} acceptors located at Ga sites of the GaAs host lattice of the NWs. An anomalous temperature dependence of the exciton emission was observed for the first time for such NWs and explained by the ionization of the acceptor states. Our measurements demonstrated that the upper limit of Mn content for the NWs obtained in the manner described above corresponds to the doping level, i.e., is much lower than the Mn/Ga flux ratio (about 3%) applied during the MBE growth. The direct evidence that a substantial accumulation of Mn takes place inside the catalyzing Ga droplets at the top of the nanowires only was also found.

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