Ordered magnetic MnAs nanocrystals embedded in III-V semiconductor nanowire shells

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Hybrid structures comprising metallic ferromagnet nanocrystals embedded in semiconductor matrices can be an alternative to dilute ferromagnetic semiconductor materials, since both are combining semiconducting and magnetic properties. The crucial issue in the former case is the control over size, distribution, and magnetic properties of nano-inclusions, providing that the method of their formation is well understood. Here we report on the well-known case of MnAs ferromagnetic metal nano-inclusions embedded in GaAs matrix, which is due to the phase separation upon high temperature (HT) annealing of (Ga,Mn)As dilute ferromagnetic semiconductor. Previously we have demonstrated the possibility of two-dimensional (2D) confinement of such magnetic nano-inclusions, in the case when the (Ga,Mn)As-GaAs superlattices have been used as the initial structures subjected to HT annealing [1]. Here we report use of quasi one-dimensional (1D) structures, namely GaAs-(Ga,Mn)As core-shell nanowires (NWs) in order to produce ensembles of magnetic MnAs nanocrystals ordered in 1D. The dimensions of MnAs nanocrystals are linked to the initial thickness of (Ga,Mn)As shells, which has been changed in the range of 5 – 20 nm. Their structure (cubic or hexagonal) can be set by the annealing temperature [2]. Additionally we have noticed that the axial positions of MnAs nanocrystals, i.e. their location along the NW cores are correlated with the stacking-fault (SF) structural defects, typical for III-V NWs. It has been demonstrated recently [3] that it is possible to create SFs “on demand” during catalyst-induced growth of zinc-blende GaAs NWs, i.e. the SFs can be periodically arranged along the NW axes. This can enable periodical arrangement of MnAs nanocrystals in the axial direction of NWs. Hence the full control over dimensions, structure and distribution of magnetic MnAs nano-inclusions in quasi 1D geometry is possible. We will show the subsequent steps towards achieving this goal, concentrating on the structural and magnetic properties of this kind of ordered hybrid structures.

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