Individual cobalt and manganese ions in quantum dots

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This work presents molecular beam epitaxy and time resolved magneto-optical spectroscopy of novel semiconductor structures with magnetic ions. We report on the first optical observation of individual cobalt ion in a CdTe/ZnTe quantum dot (QD) [1] and individual manganese ion in a CdSe/ZnSe QD [1]. Observed phenomena are compared to magneto-photoluminescence results obtained for diluted magnetic semiconductors (DMS) based on cobalt: (Cd,Co)Te, (Zn,Co)Te [2], (Zn,Co)O [3], for wide gap DMS based on manganese, such as (Zn,Mn)O [4], and for CdTe quantum dots with single Mn ions [5].

The most surprising findings are related to exciton recombination channels. For DMS structures where exciton energy is larger than intraionc transition energy, we observe excitonic photoluminescence which is weak due to quenching by magnetic ions. However, for single magnetic ions in QDs, effect of quenching is negligible. This is proved by exciton photoluminescence decay measurements which shows no difference in decay time of nonmagnetic QDs and QDs with single magnetic ions [1].

QDs containing exactly one magnetic ion exhibit characteristic photoluminescence spectrum modified by *s,p-d* exchange interaction. Exciton and biexction line is split by 6 in case of single Mn^{2+} in CdSe QD [1] (due to 6 spin projection of Mn^{2+}: ±5/2, ±3/2, ±1/2 [5]). In case of CdTe QD with individual Co^{2+}, exciton and biexction lines are split by 4 (due to 4 spin projection of Co^{2+}: ±3/2, ±1/2) [1].

We discuss impact of various effects on single magnetic ion relaxation: electronic configuration of magnetic ion, local strain, nuclear spin, and spin orbit interaction. Finally, we present fabrication of a micropillar cavity with a QD containing exactly one magnetic ion [6].

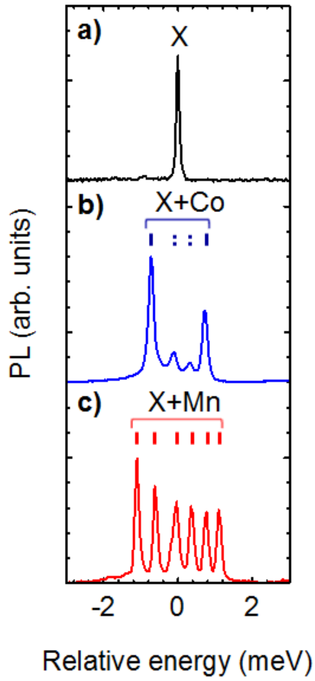

Fig. 1. *Exciton line of a QD without magnetic ion (a), with single cobalt ion (b), and with single manganese ion (c).*

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