ODMR of photoexited electrons in indirect band gap (In,Al)As/AlAs QDs with type-I band alignment

V. Yu. Ivanov[1], T. S. Shamirzaev[2], D. R. Yakovlev[3,4], M. Bayer[3,4]

[1] *Institute of Physics Polish Academy of Sciences, al. Lotnikow 32/46 02-668Warsaw, Poland*
[2] *Rzhanov Institute of Semiconductor Physics SB RAS, Novosibirsk 630090, Russia*
[3] *Experimental Physics 2, TU Dortmund University, D-44221 Dortmund, Germany*
[4] *Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021, St. Petersburg, Russia*

Optically detected magnetic resonance (ODMR) is an efficient technique to study the spin structure and spin dynamics in semiconductor nanostructures, namely in quantum dots (QDs). In direct band gap QDs application of ODMR is limited by unfavorable relation between recombination rate of excitons and pumping rate of spin system: exciton lifetime (typically less than 1 ns) is match shorter then saturation time of spin levels (typically >10 ns). Completely different situation is realized in type-I (In,Al)As/AlAs indirect band gap QDs, which exhibits exciton lifetime of up to several hundreds microseconds [1]. Here we report on first observation of ODMR of photoexcited electrons in QDs.

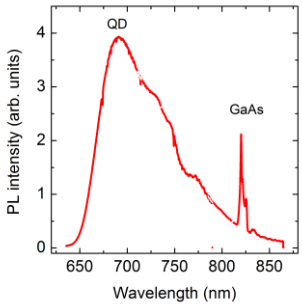

Fig.1. Photoluminescence spectrum.

Structure with undoped self-assembled (In,Al)As QDs, embedded in an AlAs matrix, was grown by molecular-beam epitaxy on semi-insulating (001)-oriented GaAs substrates. The structure has one QD sheet sandwiched between 50-nm-thick AlAs layers grown on top of a 200-nm-thick GaAs buffer layer. The nominal amount of deposited InAs was about 2.5 monolayers. ODMR experiments were performed with 60 GHz spectrometer, described in [2] at temperature T=1.86 K. The photoluminescence (PL) was excited by the third harmonic of Nd:YVO_4 laser (3.49 eV).

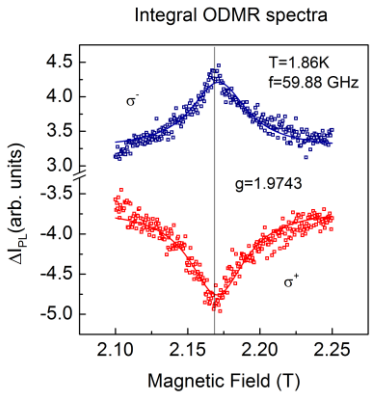

Fig.2. ODMR spectra for circular polarized components of PL spectrum.

PL spectrum measured at temperature 2 K contains two wide bands related with recombination of direct and indirect excitons from QDs and PL of bound excitons from GaAs buffer layer as it shown in Fig. 1. Longitudinal magnetic field induces circular polarization of emission. ODMR signal measured as a difference of intensity of integral exciton emission modulated by pulsed microwave power for σ+ and σ- polarization is presented in Fig.2. One can see a pronounced resonance at magnetic field of 2.17 T, related to electron from X valley of (In,Al)As QDs. Evaluated electron g-factor of 1.97 is in a good agreement to that obtained by spin-flip Raman technique [2].

Strong unresonance ODMR signal for both circular polarized components of PL was also observed. The origin of this signal could be explained by heating of electrons, localized in the potential fluctuations.

[1] T. S. Shamirzaev et al., Phys. Rev. B 84, 155318 (2011)
[2] V. Yu. Ivanov et al. Phys. Rev. B 78, 085322 (2008)
[3] J. Debus et al., Phys. Rev. B 90, 125431 (2014)