Optically Detected Magnetic Resonance of p- and n-type Doped (Cd,Mn)Te QWs

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In this work, we combine magnetooptical measurements and optically detected magnetic resonance (ODMR) technique to study magnetic system composed of Mn^{2+} ions in (Cd,Mg)Te/(Cd, Mn)Te QWs with carrier gas.

The advantage of the ODMR technique is the possibility to study local properties of magnetic ions incorporated in well-defined position of nanostructure. The basic information extracted from the ODMR spectra is the energy level structure of the Mn^{2+} ion, which depends, e.g., on the local strain [1]. Although the ODMR technique in diluted magnetic semiconductors is sensitive selectively to the magnetic ions, the detailed analysis of the measured signal reveals interactions within the magnetic ion system or between ions and charge carriers [2].

The nominally undoped (Cd,Mn)Te/(Cd,Mg)Te quantum wells are typically p-type [3]. The hole gas originates from the background doping of the (Cd,Mg)Te barrier material or from the surface states. By covering the (Cd,Mn)Te/(Cd,Mg)Te QW structure with a nickel metallic layer, we produced a sample with different carrier gas properties. As we observe by magnetooptical measurements, the hole gas is replaced by electron gas in the QW. Additionally, the application of the voltage to the nickel gate gives us an opportunity to tune the electron density.

Depending on the conditions, we have observed that the ODMR signal is affected by the carriers present in the sample in two ways. The first effect is the shift between the ODMR signals obtained on neutral and charged exciton (Knight shift). The second one is a change of the spin-lattice relaxation (SLR) rate in the presence of the carriers.

Our results clearly highlight the asymmetry between electron and hole systems. The observed change of effective g-factor in the Knight shift is positive (shift towards lower magnetic fields) and much more pronounced for p-type than for n-type case. Interestingly, for both types of carrier gas we observe significant acceleration of the SLR.

[1] Bogucki A., et al., *Phys. Rev. B* **105**, 075412 (2022).
[2] Łopion A., et al., *Phys. Rev. B* **106**, 165309 (2022).
[3] Maślana W., et al., *Appl. Phys. Lett.* **82**, 1875 (2003).