Study of spin dynamics and strain in (Cd,Mn)Te quantum well

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Magnetization dynamics measurements in diluted magnetic semiconductor (DMS) nanostructures commonly use the giant Zeeman effect which gives optical access to magnetization of magnetic ions embedded in the semiconductor crystal. However, most of methods usually require significant magnetic field [1,2]. The method proposed in Ref. [3] acquires information about spin dynamics by observation of temporal changes of photoluminescence in presence of pulsed magnetic field. Short magnetic pulses are created with a small coil placed on surface of the sample. This method allows measuring of spin dynamics down to zero magnetic field with temporal resolution of a few nanoseconds. Relaxation dynamics of Mn^{2+} spin and its changes in function of magnetic field gives insight to strain of the structure.

In this work we present results of measurements of spin dynamics in (Cd,Mn)Te quantum well (QW) with low concentration of Mn^{2+} ions. We compare experiment with numeric simulations of observed relaxation which allow to precisely determine the strain. Measurements were done in an absence and presence of constant component of magnetic field at temperature of about 1.7 K. Photoluminescence of the sample was excited by 532 nm laser. The length of magnetic pulse was in range from 5 μs to 40 μs. Photoluminescence detection system consisted of monochromator, an avalanche photodiode and time resolved photon counter synchronized with generator producing magnetic pulses. As a result of the measurement we receive spin relaxation curve which can be described by two-exponential decay. In zero magnetic field we observe only the short component of the decay with characteristic time shorter than 3 ns. This suggest that strain in investigated QW is significant [3]. To confirm this result the measurements with low constant component of magnetic field were done. Superconductive magnet produced the field up to 0.1 T, applied in Faraday configuration perpendicular to the surface of the sample. In magnetic field higher than 0.0125 T we observed that longer component of magnetization decay appears. The relative amplitude of short component decreases as a function of magnetic field and for 0.1 T vanishes completely. Characteristic time of the long component of the decay and its amplitude increases as a function of magnetic field. As a complementary part of this work we present results of numeric simulations of the Mn^{2+} relaxation reproducing observed behavior. This allow precise calculation of the strain in (Cd,Mn)Te QW. The model is based on hamiltonian presented in Ref. [4]. Results are compared with previoulsy reported spin dynamics of Mn^{2+} ions embedded in a QW showing lower strain than the present one.

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