Coupling of quantum dots with quantum wells in a system based on (Cd,Mg)Te

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Coupled quantum systems are very desirable structures due to potential applications in spintronics and quantum computing. Particularly interesting are coupled objects with different dimensionality, like quantum wells (QWs) – 2D structures, and quantum dots (QDs) – 0D structures. By combining such different object, one can think about unusual combination of physical properties. For example, spin relaxation in QWs, and in particular magnetic QWs, is very fast, but it is rather low in QDs or QDs containing single magnetic ions. Therefore structure with coupled QWs and QDs could be used for efficient spin orientation of carriers in QWs and further injection of such polarized carriers to QD, where spin will be preserved long time. Polarization of carriers in QDs can be subsequently transfer to magnetic ions, and in particular to single magnetic ion in a QD.

However, there are important problems in designing above coupled structures. For efficient tunneling QW energy should be equal to, or slightly larger than, QDs energy, but due to quantum confinement, larger objects like QWs exhibit typically higher energy than smaller object like QDs, if they are made of the same semiconductor. Moreover, QWs should be not strained too much, QDs are typically formed in strained structure. Therefore, it is difficult to find good material combination for realization of coupled QWs and QDs.

We propose coupled QWs and QW dots based on (Cd,Mg)Te system, where QW is made of (Cd,Mn,Mg)Te with low Mg content, barrier is made of (Cd,Mg)Te with high Mg content, and QDs are made of CdTe:Mn. Our system is realized using molecular beam epitaxy and investigation are based on optical spectroscopy at low temperatures. Optical spectra confirm that energy of obtained QWs is slightly higher than energy of QDs. Moreover, in a series of samples with various position of QD versus QWs, we observe either rapid transfer of energy from QWs to QDs, or efficient luminescence of QWs.