Optical Studies of Mn^{2+} Spin Resonance in CdMnTe Quantum Wells

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The optical properties of diluted magnetic semiconductors and their quantum well structures have been widely investigated from the viewpoint of the modification of the electronic states induced by the presence of magnetic ions. The reciprocal effect of the influence of electronic states on magnetic ions has been less studied, particularly in the case of quantum well structures for which the small number of magnetic ions makes them difficult to be detected in traditional EPR or magnetisation measurements. Below we report the investigation of Mn^{2+} magnetic resonance in CdMnTe quantum well structures by means of purely optical methods: resonant Raman scattering and optically detected magnetic resonance. Both methods show that the classical description of Mn^{2+} ions in terms of isolated paramagnetic S = 5/2 spins is inadequate in these systems, in spite of the low concentrations of Mn^{2+}.

We have studied single quantum well structures consisting of a modulation doped CdMnTe magnetic well between nonmagnetic barriers of CdMgTe. Raman scattering studies were performed in the backsattering geometry, using a double-grating spectrometer. For the optically detected resonance (ODMR) measurements changes in the photoluminescence spectrum were monitored as the sample was irradiated with microwaves and the magnetic field slowly swept through resonance.

In the Raman scattering experiments, we observe multiple spin-flip transitions of the Mn^{2+} ions, with a number of transitions greater than 5 in both Voigt and Faraday backscattering geometry in external magnetic fields up to 28 T. The observation of multiple Mn^{2+} spin-flip transitions in the Voigt geometry is in agreement with previous reports [1]; however, the existence of multiple spin-flips in the Faraday configuration is not predicted by the above theory, and their observation is surprising. Furthermore, the maximum peak intensity of consecutive peaks follows an exponential function, as distinct from the Poisson distribution reported [1] for the Voigt geometry.

The ODMR measurements showed a significant blue shift of the photoluminescence spectrum at the magnetic field corresponding to Mn^{2+} spin transitions at the energy of the incident microwaves. This blue shift, when plotted against the magnetic field, exhibits a complicated structure, suggestive of a hyperfine splitting due to interactions between Mn^{2+} electronic and nuclear spins. However, their number was greater than the expected number of hyperfine transitions (6).

Together, these observations clearly demonstrate that the behaviour of Mn^{2+} ions in a quantum well requires a description taking into account the exchange interactions with free carriers, and cannot be considered as simple paramagnetic spin 5/2 ions.

[1] J.Stühler, G.Schaack, M.Dahl, A.Waag, G.Landwehr, K.V.Kavokin, I.A.Merkulov, Phys. Rev. Lett. **74**, 2567 (1995)