Optical control of Mn^{2+} ions in GaAs

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A pathway to optical spin manipulation in semiconductors is to implement magnetic ions in and exploit the strong exchange interaction between an electron (hole) and a magnetic ion. GaAs doped with Mn acceptors of low concentration (below 10^{18} cm^{-3}) represents an attractive model system for investigation of carrier-magnetic ion interaction. First, Mn in GaAs is an acceptor where the p-d exchange interaction with the valence band hole significantly changes the energy structure of the acceptor complex. Second, s-d interaction with photoexcited electrons localized in the vicinity of Mn acceptor provides the channel for the spin transfer between the electron and Mn systems. Partial compensation by residual shallow donors with a concentration of about $10^{16}cm^{-3}$ leads to appearance of ionized acceptors (Mn^{2+} ions) located in the vicinity of donors if not illuminated by light. Isolated Mn^{2+} ions possess very long spin relaxation time (~ 10 μs) and therefore can be used for realization of spin storage.

Here we present an overview of recent investigations of electron spin dynamics in paramagnetic GaAs:Mn. The results include experimental data from time-resolved Kerr and Faraday rotation, time-resolved photoluminescence and spin-flip Raman scattering [1,2]. We show that optical orientation of Mn ions is possible under application of low magnetic field, which is required to suppress the manganese spin relaxation. The optically oriented Mn^{2+} ions maintain the spin and return part of the polarization back to the electron spin system providing a long-lived electron spin memory.

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