Transport in magnetic semiconductors and oxides

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Colossal negative magnetoresistance and the associated field-induced insulator-to-metal transition, the most characteristic features of magnetic semiconductors, are observed in n-type rare earth oxides and chalcogenides, p-type manganites, n-type and p-type diluted magnetic semiconductors (DMS) as well as in quantum wells of n-type DMS. This phenomenon results from a complex interplay between magnetism and localisation of carriers by disorder.

As an introduction to the relevant physics [1], the notion of Anderson-Mott localisation will be introduced. Two kinds of interference phenomena accounting for the appearance of quantum corrections to the Drude-Boltzmann conductivity will be discussed. It will be shown that the presence of localized spins exerts a strong influence on quantum localization in doped semiconductors. At the same time carrier-mediated interactions between the localized spins are modified or even halted by carriers' localization. It will be then demonstrated how these effects lead to a complex field and temperature dependence of resistance that is being observed in magnetically doped semiconductors and oxides.

We will then discuss experimental results on electron and hole spin injection, tunnelling magnetoresistance and current-induced magnetisation switching in trilayer structures as well as domain-wall resistance and displacement in ferromagnetic DMSs, particularly (Ga,Mn)As [2]. These findings can be described in terms of theory that combines an empirical tight-binding approach with a Landauer-Büttiker formalism. Thus, in contrast to the standard *kp* method, it describes properly the interfaces and inversion symmetry breaking as well as the band dispersion in the entire Brillouin zone, so that the essential for the spin-dependent transport Rashba and Dresselhaus terms as well as the tunneling *via* ***k*** points away from the zone center are taken into account. Furthermore, since in most semiconductor spin transport devices the relevant length scale is shorter that the phase coherence length, the application of the Landauer-Büttiker formalism is more suitable than approaches based on kinetic Drude-Boltzmann equations.

1. T. Dietl, *J. Phys. Soc. Jpn. 77*, 031005 (2008).
2. see, "Spintronics", in: *Semiconductors and Semimetals*, vol. 82, eds. T. Dietl, D.D. Awschalom, M. Kaminska, H. Ohno (Elsevier, Amsterdam, 2008).

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