Anisotropy of the RRKY interaction in ferromagnetic (Ga,Mn)As

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Ultrathin layers of the dilute ferromagnetic semiconductor (Ga,Mn)As have been studied recently by the method of subsequent chemical thinning and oxidizing steps [1]. The reported monotonic reduction of Curie temperature has been attributed to a gradient of the material properties (defect concentration) and the surface effect (donor traps). A vertical gradient of the effective magnetic anisotropy has been reported in [2]. In this contribution we investigate theoretically if the finite size itself may have an effect on the layer properties such as the perpendicular magnetic anisotropy. We also find that the microscopic mechanism which we consider significantly affects the predictions for the in-plane uniaxial component of the magnetic anisotropy.

The ferromagnetic interaction in (Ga,Mn)As is mediated by *p*-type carriers (RKKY interaction), which are subject to the spin-orbit interaction. Therefore, the anisotropy of the exchange interaction in the spin space is dependent on the spatial coordinates (relative position of the interacting spins or the wave vector of the applied perturbation). In the mean field approximation this translates into e.g. a thickness dependence of the perpendicular magnetic anisotropy. We find such a contribution to the magnetic anisotropy significant for layers thinner than about 10 lattice constants.

On the other hand, (Ga,Mn)As exhibits an in-plane uniaxial magnetic anisotropy, whose origin has been puzzling the researchers for a long time, and which we recently assigned to an asymmetry in the nanoscale distribution of the magnetic impurity predicted by an *ab initio* study [3]. Here, the spatial asymmetry of the impurity distribution translates into a contribution to the magnetic anisotropy, which is not captured by the Zener model [4] employed in [3].

We compare the total magnitude of the in-plane uniaxial anisotropy calculated according to this method (effective strains in the Zener model together with the RKKY contribution) with the results of a direct *ab initio* approach.

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