Domain wall resistance and interface Lorentz magnetoresistance in thin films

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Contributions of domain walls and the domain structure to the magnetoresistance (MR) have been investigated and discussed intensively in the past years [1]. Recent experiments indicate the existence of a domain resistance in thin films of FePt, FePd, Fe and Co, which cannot be explained by contributions of bulk anisotropic MR (AMR) and bulk Lorentz MR (LMR) within domains [1-4]. This discrepancy has been attributed in parts to an intrinsic domain wall resistance (DWR) and, on the other hand to additional magnetoresistance contibutions related to the domain structure. Berger showed that the Hall effect and the extraordinary Hall effect cause a MR anisotropy in stripe domains [2]. The "negative domain wall resistance" observed in Fe films has been attributed to a reduction of scattering at the film surface in the presence of a domain structure [1]. We report numerical results on the Lorentz magnetoresistance of ferromgnetic thin films with domain structure (called interface LMR in the following). The simulations are based on the Einstein relation between conductivity and diffusion constant, where the diffusion constant is obtained as an ensemble average of caluculated trajectories. In order to check our model, old analytical results on the magnetoresistance in thin films obtained from the Sondheimer theory are reproduced, as well as the result of Berger mentioned before. The latter effect is shown to be destroyed by surface scattering in the case of a mean free path larger than either the film thickness or the domain size. Experiments on Fe and Co films are discussed [3,4]. In summary, the domain resistance known as "negative DWR" is consistent with interface LMR. In cobalt films with perpendicular magnetization and closure domains, the influence of closure domains on the MR anisotropy is given by the AMR contribution only if the mean free path approaches the domain size, as observed in the experiment [5]. In contrast, the MR anisotropy related to oriented perpendicular stripe domains in FePt and FePd, cannot be related to interface LMR.

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