Domain wall dynamics in diluted ferromagnetic semiconductors

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Domain wall (DW) dynamics in ferromagnetic materials has been the subject of a renewed interest in the past years owing to potential application to novel types of magnetic memories. Although numerous studies focus on current-induced domain wall propagation, a thorough understanding of the dynamics also requires the investigation of field-driven DW propagation. Besides, from a fundamental point of view, there is a need for a more accurate theoretical description of DW dynamics, beyond the framework of the well-known one-dimensional (1D) model, since many experimental results point to its limitations. Ferromagnetic semiconductors like (Ga,Mn)As and its phosphorus substituted compounds (Ga,Mn)(As,P) offer fascinating possibilities to investigate DW propagation. Firstly, the density of domain wall pinning defects can be made sufficiently low to overcome the pinning regime and reach intrinsic flow regimes. Secondly, owing to the carrier-mediated nature of the ferromagnetism, the micromagnetic parameters determining the velocity behavior (saturation magnetization, spin-stiffness constant, magnetic anisotropy, Gilbert damping) can be tuned by various means (Mn concentration, epitaxial strain, P alloying) unlike metals. We will review a number of experimental results obtained in GaMnAs and GaMnAsP thin layers using magnetic domain imaging and a field pulse technique. In GaMnAs layers the intrinsic flow regime was evidenced for the first time in ferromagnetic semiconductors [1]. Varying the layer thickness has highlighted the role of bending instabilities of the wall propagation dynamics leading to a novel description of DW propagation beyond the 1D-model [2]. Results on (Ga,Mn)(As,P) layers show very high DW velocities of several hundred m/s. By varying the magnetic anisotropy, the nature of the regime observed (depinning or flow) has been determined [3]. [1] A. Dourlat et al., Phys. Rev. B 78, 161303(R) (2008). [2] L. Thevenard et al., Phys. Rev. B 83, 245211 (2011). [3] L. Thevenard et al., Phys. Rev. B 85, 064419 (2012).