Interactions between Domain Walls and Spin-polarized Currents

(Ulrich Rüdiger)

Abstract :

Novel approaches to switching small magnetic structures are currently heavily investigated. A promising new approach is switching by current-induced domain wall propagation (CIDP) where due to a spin torque effect, electrons transfer angular momentum to a head-to-head domain wall and thereby push it in the direction of the electron flow without any externally applied fields.

We use magnetoresistance measurements and XMCD-PEEM to directly observe domain wall propagation in-situ in ferromagnetic nanostructures induced by current pulses. We determine the propagation distances as a function of pulse height and pulse length for different types of domain walls (vortex and transverse). The high resolution microscopy allows us to image the nanoscale spin structure of the walls after injection of currents and we observe that the current modifies the spin structure dramatically [1]. For a deeper understanding of the effect, we compare our results to theoretical predictions.

Temperature dependent measurements of field- and current-induced wall motion have shown that the critical fields for field-induced wall motion decrease with increasing temperature, which can be attributed to thermal excitations. The critical current densities for current-induced motion though have been found to increase with increasing temperature, which is opposite to the behaviour due to thermal excitations, and might be due to the influence of thermally activated spin waves [2].

For applications in data storage devices like the race track memory suggested by S.S.P. Parkin a controlled pinning/depinning of domain walls in a tailored potential landscape is an essential prerequisite. Geometrically confined domain walls are either attracted or repelled by geometrical constrictions. This behaviour lends itself to a descrition of magnetc domain walls as quasiparticles moving in a potential well. Current-induced domain wall excitations at the resonance frequency give rise to a significant reduction of the critical magnetic field or current to drive a domain wall out of the pinning center [3].

[1]

[2]

[3]