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Spin-polarized currents interact with the magnetization of a ferromagnet which opens new opportunities to design magnetic memory and logic devices. A local variation of the magnetization is necessary for the occurrence of spin-torque. Here we present results on the interaction between spin-polarized currents and magnetic vortices as well as domain walls in permalloy nanostructures [1]. Experiments are performed in the frequency as well as in the time domain.
One focus is to investigate the harmonic excitation of a vortex in a square magnetic thin-film element with spin-polarized currents which results in a frequency dependent rotation of the vortex around its equilibrium position. This is theoretically predicted [2] and has been shown in real space for excitation with magnetic fields [3]. The resonance frequency of micron-sized permalloy squares is typically below 1 GHz. The experimental challenge is to design a square with a low resonance frequency i.e. a weak confining potential and to ensure the existence of the vortex-state. We analyzed the micromagnetic behaviour of our permalloy squares by magnetic-force microscopy and measurement of the anisotropic magnetoresistance (AMR). Supported by micromagnetic simulations we can conclude that the squares can be switched either into the s-state or into the vortex-state. A current induced excitation increases the resistance because of the energy dissipation [4]. We measure this using a LCR-Hitester and scalar network analysis.
The second focus is on current induced vortex and domain-wall motion measured in the time domain. Using X-ray microscopy with a spatial resolution down to 15 nm and a stroboscopic pump and probe measurement scheme with resolution in the 100 ps time scale, current induced vortex and domain-wall oscillation are observed. The domain wall is prepared in a nanostructure with a restoring potential. During a pulse the domain wall is displaced and afterwards starts a free oscillation with strong damping.

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