Spin dynamics due to spin-transfer in symmetric and asymmetric spin-valves

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Spin transfer between conduction electron system and localized magnetic moments gives rise to new phenomena, like for instance current-induced switching between different magnetic states [1]. At certain conditions electric current can cause transition to steady precessional modes, where the energy is pumped from conduction electrons to localized magnetic moments. This phenomena is of high importance due to possible applications in microwave generation. In systems studied up to now the precessional modes were found in a nonzero external magnetic field [2]. In typical Co/Cu/Co spin valves that contain thick (fixed) and thin (sensing) magnetic layer separated by nonmagnetic spacer layer, the steady precessions exist for external fields larger than the anisotropy field of the sensing layer and currents exceeding certain critical values. For the practical point of view, it is highly desired to have systems where the steady precessions can occur at zero magnetic field, and the microwave frequency can be controlled by an external voltage only. We have found that spin-transfer torque in asymmetric systems, with the two magnetic layers having different bulk and interface spin asymmetry factors, like Co/Cu/Py nanopillars, vanishes at a certain noncollinear magnetization configuration due to inverse spin accumulation. As a result, spin current can destabilize both parallel and antiparallel magnetic configuration for one orientation of the bias current and stabilize both configuration for the opposite current. The former case can lead to current-induced precessional modes in zero external magnetic field.

The current-induced dynamics of magnetic moments in the spin valve structures is studied theoretically using a macroscopic model of spin transfer torque and numerical solution of the Landau-Lifshitz-Gilbert equation. The latter equation is generalized by including the spin transfer torque, which has been determined from the classical spin diffusion theory and macroscopic boundary conditions for the longitudinal and transverse components of the spin current [3]. The description includes parameters which can be taken from experiments on CPP-GMR, like bulk and interfacial spin asymmetry parameters, spin-diffusion lengths, bulk and interface resistances.

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[1] J.C. Slonczewski, J. Magn. Magn. Mater. **159** (1996) L1; L. Berger, Phys. Rev. B **54** (1996) 9353.
[2] S.I. Kiselev *et al*., Nature **425** (2003) 380; S.I. Kiselev *et al*., Phys. Rev. B **72** (2005) 064430.
[3] J. Barnas *et al.*, Phys. Rev. B **72** (2005) 024426.

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