TRANSPORT-DEPENDENT CURRENT-INDUCED SWITCHING OF SYMMETRIC AND ASYMMETRIC SPIN VALVES

P. Baláž[1], M. Gmitra[2], E. Jaromirska[3], L. Lopez-Diaz[3], J. Barnaś[1, 4]
[1]*Department of Physics, A. Mickiewicz University, Poznań, Poland*
[2]*Institute of Physics, P.J. Šafárik University, Košice, Slovakia*
[3]*Departmendo de Fisica Aplicada, University of Salamanca, Spain*
[4]*Insitute of Molecular Physics, Polish Academy of Science, Poznań, Poland*

Spin-polarized current can transfer spin angular momentum from conduction electrons to localized magnetic moments and generate magnetic switching and excitations. This phenomenon is important for its wide range of technological applications, including magnetic memory and magnetic sensors. Therefore designing of new bistable devices able to be fast switched by electric current as well as thorough understanding of the current-induced spin dynamics are needed.

Hence we have performed relevant dynamical study of the standard spin valve Py/Cu/Py and another one Co/Cu/Py with asymmetric structure, both connected to Cu electrodes. The in-plane and out-of-plane spin transfer torque components dependent on angle between magnetizations of magnetic layers have been calculated in both, diffusive and ballistic spin transport limits. The dynamics has been simulated making use of macrospin model, using the generalized Landau-Lifshitz-Gilbert equation.

We examined the dynamical properties of mentioned heterostructures under influence of electric current. Special attention has been taken to spin switching under rectangular current pulses of certain amplitude and duration. Optimal pulse parameters leading to minimal switching time have been found in the case of symmetric as well as asymmetric spin valve and the effect of different transport type has been discussed. Moreover, the simultaneous presence of both transport types has been considered.

The difference of spin asymmetries in magnetic layers of Co/Cu/Py valve leads in case of diffusive transport to non-standard wavy-like angular dependence of the spin torque, which significantly differs from the ballistic regime case. Additionally, the wavy angular dependence causes that the only solution of the spin dynamics under constant current is the steady state precession or a stable static state with a noncollinear orientation of the magnetic moments. In this case both collinear states are destabilized and the valve is hard to be switched only with a current pulse. By this reason we propose a switching scheme making use of two sequential pulses of current and magnetic field, dependably leading to desired collinear spin organization.

Finally, the thermal effects have been considered and modeled by an additional stochastic magnetic field. The thermal stability of proposed switching scheme and constructed switching diagrams has been checked and the statistical switching properties in case of both transport limits have been compared.

This work was supported by the EU through the Marie Curie Training Network SPINSWITCH (MRTN-CT-2006-035327).