CURRENT-INDUCED SPIN-TRANSFER TORQUE IN MAGNETIC TUNNEL JUNCTIONS

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In tunnel junctions with ferromagnetic electrodes due to transfer of spin from conduction electrons to localized magnetic moments a torque can be generated which can lead to switching of the electrode's magnetization. As magnetic configuration of the junction can be changed the phenomenon may be important for applications in magnetic memory elements. The current-induced magnetic switching (CIMS) was studied experimentally mainly for metallic nanopillars [1], however, recently, the effect has been also observed in tunnel junctions [2].

Spin-polarized transport in planar tunnel junctions is analyzed within the framework of free-electron-like model and the current-induced torque is discussed. In contrast to metallic structures, in tunnel junctions, two components of the spin torque, the in-plane and the normal ones, should be taken into account and both components strongly influence dynamics of magnetic moments. The in-plane component is lying in the plane determined by the magnetic moments of both electrodes and the normal one is perpendicular to the plane. The magnitude of both torque components is maximal for the perpendicular orientation of the magnetic moments in the electrodes and vanishes in the collinear configurations. The spin torque components vary in a different way as a bias voltage is increasing. The out-of-plane component shows a parabolic-like dependence, whereas the in-plane one is asymmetric with respect to bias reversal even in symmetric junctions. The torque strongly depends on spin polarization of electrodes and junction parameters, such as a height and thickness of the barrier. In junctions with thick and low barriers the torque can change a sign.

When one of the electrodes is replaced by a very thin ferromagnetic layer torque components show oscillatory-like dependence on the layer thickness which is a consequence of quantum spin-well effects and charge currents oscillations in each spin channel. Oscillation periods are determined mainly by the wavelength of electrons from the Fermi level in the source electrode, which tunnel normally through the barrier. Moreover, the torque may change a sign when the thickness of the ferromagnetic layer is varied.

Some preliminary results obtained for double junctions will be also presented. In such junctions both torque components exerting on a thin central layer depend strongly on the layer thickness and can be essentially enhanced for a special thickness of this layer. The torque dependence on the angle between orientations of magnetic moments in the central layer and in electrodes appears to be more complex than in a single junction.

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