SPIN DYNAMICS IN MAGNETIC MULTILAYERS

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Magnetic multilayers provide a special case where dynamic interactions between the itinerant electrons and the magnetic moments in ultrathin films offer new possibilities compared to bulk materials. The precessing magnetization acts as a peristaltic spin pump, which transports the spin momentum away from the ferromagnet (F). In contrast to the well-known oscillatory exchange interaction in the ground state, this coupling is dynamical in nature and long ranged. In magnetic bilayers F/N/F, the transverse component of the spin current in non-magnetic spacer, N, is entirely absorbed at the N/F interface. This means that the N/F interface acts as an ideal spin sink providing an effective spin brake for the opposite ferromagnetic layer F, which results in an additional magnetic interface damping that obeys the Gilbert phenomenology. Experimental studies have been carried out using crystalline Au/Fe/Au/Fe/GaAs(001), Pd/Fe/GaAs(001), and Au/Fe/Au/Pd/Fe/GaAs(001) multilayers. The quantitative comparison with spin pumping theory is very good for Fe/Au/Fe structures. First principles electron band calculations of the spin mixing conductance $\sigma_{\uparrow\downarrow}$ result in Gilbert damping, which is in a nearly perfect agreement with the measured non-local, interface damping. The spin transport across Pd spacers is different compared to that in Au spacers. The spin current is strongly attenuated by interaction with fluctuating moment in Pd. The propagation of the spin current becomes more complex in heterogeneous Pd/Au spacers. It will be shown that the propagation of the spin current in Pd/Au (001) spacers is affected by a partial reflection of spin current at the Pd/Au interface. The Pd lattice has a large lattice mismatch with respect to Fe. For the Pd layers thicker than 5ML the lattice strain is partially released by a rectangular network of misfit dislocations. It will be shown that the formation of a self-assembled nano network of misfit dislocations leads to a strong extrinsic magnetic damping. The out of plane measurements of the FMR linewidth have revealed that the extrinsic damping is caused by two magnon scattering. This system provides an ideal opportunity to investigate the role of two magnon scattering in a wide range of microwave frequencies. FMR measurements were carried out from 4 GHz to 73 GHz. The contribution to the FMR linewidth from two magnon scattering is strongly anisotropic and follows the rectangular symmetry of the glide planes of the misfit dislocation network. The angular dependence of the FMR linewidth is a consequence of an effective channeling of the scattered spinwaves. The extrinsic damping often results in FMR linewidth above 10GHz that increases linearly with microwave frequency but is accompanied by a zero frequency offset. Two magnon scattering in Pd/Fe systems is no exception. It will be shown that this behavior is not followed in the lower range of microwave frequencies. The FMR linewidth eventually shows a rapid decrease towards zero, resulting in a large effective Gilbert damping which can surpass the intrinsic contribution to Gilbert damping by two orders of magnitude.

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