Modelling of magnetization oscillations’ excitation by surface acoustic waves in metal films

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The work is devoted to modelling of nonlinear and parametric interactions between surface acoustic waves and magnetic oscillations in thin metal films. We consider the geometry of elastic strains excitation on the surface of metal film by femtosecond laser light influence. The case of elastically driven magnetization precession excitation including the magnetostatic surface spin waves is observed.

The scheme of excitation has periodic grating forming that is created by interference of two femtosecond laser light rays on the film surface and the elastic strains are formed in this grating by the thermal influence of light [1]. DC magnetic field was applied in the plane of the film deposited on a nonmagnetic dielectric substrate. In this geometry the expression for the density of magnetoelastic interaction energy and the components of deformation tensor which are responsible for magnetoelastic interaction were found. The magnetization dynamics are forced (via inverse magnetostriction) by two surface-confined elastic waves: Rayleigh Surface Acoustic Wave (SAW) and Surface Skimming Longitudinal Wave (SSLW) [1]. The excitation of FMR harmonics and frequency-mixing by elastic waves were calculated within the framework of a theoretical model taking into account the Landau-Lifshits-Gilbert (LLG) equation, boundary conditions for the magneto-elastic stresses and the equations for the elastic displacements. The alternating magnetoelastic field is determined by SAW and SSLW strain components. The equations for the magnetic oscillations were derived by first and second order perturbation theory. The parametric interaction of the elastic waves with a magnetic oscillator leads to frequency-mixing SAW+SAW, SAW+SSLW and SSLW+SSLW. The connection between the amplitude of the magnetic oscillations and internal magnetic field orientation in film plane was found. The interval of field orientation from the direction parallel to interference stripes to the direction for these stripes perpendicular was investigated. We also consider the numerical solutions of LLG equation to obtain the dispersion curves for magnetostatic surface spin waves. The possibility of the waves excitation by SAW and SSLW was shown. Connected with the heat flow in the grating magnetoelastic dynamics also was considered. We compare our theoretical results with the obtained in the work [1] experimental dependencies of the Faraday rotation on the DC magnetic field.

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[1] C.L. Chang et al., Phys. Rev. B **95**, 060409(R) (2017).