COUPLED SPIN-ELECTROMAGNETIC WAVES IN ALL-THIN-FILM MULTIFERROIC MULTILAYERS

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Increased demands to frequency-agile materials for microwave devices has led to appearance of artificial multiferroics [1]. These materials are usually fabricated with a combination of ferrite and ferroelectric layers so as to obtain micro- and nanostructures [2, 3]. A distinctive feature of the multiferroics is dual (electric and magnetic) tunability of their electrodynamic properties. The tunability is provided by electrodynamic coupling of the spin waves (SWs) and electromagnetic waves in the ferrite-ferroelectric layered structures [4]. These coupled excitations are referred to as spin-electromagnetic waves (SEWs). As it was shown earlier, the effective coupling at microwave frequencies is achieved in the structures fabricated with a relatively thick (200-500 μm) ferroelectric layers [5]. Such thicknesses of the ferroelectric layer lead to relatively high control voltages (up to 1000 V) needed for an effective electric tuning of the SEW dispersion.

The purpose of the present work is to report on a new mechanism which provides an effective tuning of the SEW dispersion in planar all-thin-film multiferroic structures. This mechanism can be implemented by tunable interaction of the coupled SWs propagating in a heterostructure consisting of two ferrite layers separated by a thin ferroelectric film. It is due to a change in electrodynamics coupling between SWs in the neighboring ferrites with a reduction of permittivity of a thin ferroelectric film positioned between the ferrites. It is shown that an effective electric-field tuning is possible even with the use of the 1-μm-thick ferroelectric film. As is well known, the efforts aimed to a ferroelectric-film thickness reduction arise from the demands to reduce the control voltage. Therefore, the studied multiferroic structure looks promising for practical applications, in particular, for development of the thin-film microwave phase shifters. This work was supported in part by Academy of Finland.

[1] M. M. Vopson, Critical Reviews in Solid State and Materials Sciences. 40(4), 223-250 (2015).
[2] C. Lu et. al. Applied Physics Reviews. 2, 021304(1-19) (2015).
[3] N. X. Sun, G. Srinivasan, Spin. 2(3), 240004(1-46) (2012).
[4] V. E. Demidov, B. A. Kalinikos, P. Edenhofer, J. Appl. Phys. 91(12), 10007(1-10) (2002).
[5] V. E. Demidov et.al. IEEE Transactions on MTT. 51(10), 2090-2096 (2003).