Influence of CoFeB layer thickness on elastic parameters in CoFeB/MgO heterostructures

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Surface acoustic waves (SAWs), i.e. phonons (quasiparticles of SAWs) are elastic waves propagating along the surface of an elastic material with decreasing amplitude with the depth of the material [1]. SAW-based devices has become an integral part of our daily lives [2]. They may also have potential applications in future spintronic devices if coupled with other waves (e.g. spin waves (SWs)) and/or quasiparticles. So, it is quite important to understand the coupling of phonons with other quasiparticles and enhance the coupling efficiency, especially in magnetic thin film heterostructures such as CoFeB/MgO, one of the most promising materials for future spintronics applications [3]. As a first step it is important to understand how elastic parameters of magnetic heterostructures and properties of acoustic phonons evolve with the CoFeB layer thickness.

Here, we have investigated SAWs in CoFeB/MgO multilayers by probing thermally generated acoustic phonons by Brillouin light scattering (BLS) spectroscopy to find out effective elastic parameters of the multilayers with varying CoFeB thickness. The multilayer structures: Ta(10)/$Co_{20}Fe_{60}B_{20}$(t=1 to 20)/MgO(2)/Al_2O_3(10) are deposited on Si[001]/SiO_2(700) substrates (the numbers in parentheses are the nominal thicknesses of layers in nm). We observe that the group velocity of Rayleigh-type SAWs decreases with increasing CoFeB layer thickness and the phase velocity of Rayleigh waves is lower in studied multilayers as compared to Si/SiO_2 substrate. The experimental results are corroborated with Finite element method (FEM) based simulations, which helped us to estimate the elastic parameter of the individual CoFeB layer. Additionally, we estimate the effective elastic parameters (elastic tensors, Young's modulous, Poisson's ratio) of the whole stacks for varying CoFeB thickness. Interestingly, the simulated dispersion characters of SAWs with both types of parameters show very good agreement with the experimental results. These estimated elastic parameter will be quite useful to investigate magnon-phonon interaction in CoFeB/MgO heterostructures.

References:

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