The influence of underlayer on surface acoustic waves velocity in underlayer/CoFeB/MgO heterostructures

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Surface acoustic waves (SAWs) are confined near the surface in an elastic material. The quasiparticle associated with SAWs are known as phonons, analogous to photons for light waves. The SAW-based devices find applications in our daily life due to their high sensitivity and broad operational frequency. They also have potential to be used in future spintronics devices if coupled with, e.g. spin waves (SWs). Because of such importance, a detailed study on the properties of SAWs is required, especially, in magnetic thin film heterostructures such as CoFeB/MgO, a promising candidate for future spintronics applicatons [1-4].

Hence, we adapted Si/SiO_2(substrate)/X/$Co_{20}Fe_{60}B_{20}$(1.4)/MgO(2)/Al_2O_3(10) heterostructures to investigate the evolution of SAWs properties and elastic parameters with the underlayer (X). We chose Ta(10), W(10), Pt(10), Ta(5)/Ru(20)/Ta(5) as underlayer to systematically vary the material density and mass loading. The Brillouin light scattering (BLS) spectroscopy was employed to probe thermally generated acoustic phonons in those multilayers. From the measured dispersion relations, we observe that the group velocities of SAWs decrease with increasing density of the underlayer material (Ta $<$ W $<$ Pt) and increasing total mass (for Ta/Ru/Ta). Moreover, the Rayleigh-type SAW velocity in the multilayers is lower than that of Si substrate. We also performed simulation based on finite element method (FEM), which further supports our experimental results. We find that the varying density of underlayer materials efficiently changes the effective elastic properties of composite layer and thus the properties of phonons. We estimate the effective elastic parameters of multilayers with varying underlayer. This study is our first step towards the investigation of coupling of SAWs with SWs in CoFeB/MgO heterostructures.

References:

[1] K. Tsunekawa *et al.* *Appl. Phys. Lett.* 87, 072503 (2005).
[2] J. M. Teixeira *et al.* *Mater. Sci. Eng. B* 126, 180–186 (2006).
[3] Y. Zhang *et al.* *J. Appl. Phys.* 115, 17D509 (2014).
[4] S. Ikeda *et al.* *Nat. Mater.* 9, 721–724 (2010).

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