

Supplimentary for Multilayer repetition controls surface acoustic wave propagation and anisotropic elastic response in CoFeB/Au systems

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S1 Calculation of effective elastic tensor and density

The investigated samples consist of Ti/Au buffer layer and a periodic [CoFeB/Au] multilayer with N repetitions. The total thickness of the stack is given by

$$h_{\text{total}} = t_{\text{Ti}} + t_{\text{Au,buffer}} + N(t_{\text{CoFeB}} + t_{\text{Au}}), \quad (1)$$

where t_{CoFeB} , t_{Ti} , and t_{Au} represent the individual layer thicknesses of CoFeB, Ti, and Au, respectively. We define the total buffer thickness as

$$t_{\text{buffer}} = t_{\text{Ti}} + t_{\text{Au,buffer}}. \quad (2)$$

The three independent elastic constants of $\text{Co}_{20}\text{Fe}_{60}\text{B}_{20}$ are estimated using a composition-weighted average (rule of mixtures):

$$c_{11}^{\text{CoFeB}} = 0.2 c_{11}^{\text{Co}} + 0.6 c_{11}^{\text{Fe}} + 0.2 c_{11}^{\text{B}}, \quad (3)$$

$$c_{12}^{\text{CoFeB}} = 0.2 c_{12}^{\text{Co}} + 0.6 c_{12}^{\text{Fe}} + 0.2 c_{12}^{\text{B}}, \quad (4)$$

$$c_{44}^{\text{CoFeB}} = 0.2 c_{44}^{\text{Co}} + 0.6 c_{44}^{\text{Fe}} + 0.2 c_{44}^{\text{B}}. \quad (5)$$

where c_{11}^{Co} , c_{11}^{Fe} and c_{11}^{B} correspond to the elastic tensors of cobalt, Iron and Boron respectively.

Under the long-wavelength approximation, the effective elastic tensor of the buffer layer is calculated as a thickness-weighted average of Ti and Au:

$$c_{ij}^{\text{buffer}} = \frac{t_{\text{Ti}} c_{ij}^{\text{Ti}} + t_{\text{Au,buffer}} c_{ij}^{\text{Au}}}{t_{\text{buffer}}}, \quad (6)$$

and the effective elastic tensor of the full stack is

$$c_{ij}^{\text{eff}} = \frac{t_{\text{buffer}} c_{ij}^{\text{buffer}} + N(t_{\text{CoFeB}} c_{ij}^{\text{CoFeB}} + t_{\text{Au}} c_{ij}^{\text{Au}})}{h_{\text{total}}}. \quad (7)$$

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Table S1: The elastic constants of the materials Co, Fe, B, and the studied samples [CoFeB/Au]₁₅ and [CoFeB/Au]₂₀.

Elastic Constant	Cobalt	Iron	Boron	[CoFeB/Au] ₁₅	[CoFeB/Au] ₂₀
C_{11} (GPa)	212	226	454	228.03	231.29
C_{12} (GPa)	121	133	50.9	143.05	142.96
C_{44} (GPa)	52	114	210	80.91	83.98

Similarly, the effective density of the buffer is

$$\rho_{\text{buffer}} = \frac{t_{\text{Ti}} \rho_{\text{Ti}} + t_{\text{Au,buffer}} \rho_{\text{Au}}}{t_{\text{buffer}}}, \quad (8)$$

and the effective density of the full stack is

$$\rho_{\text{eff}} = \frac{t_{\text{buffer}} \rho_{\text{buffer}} + N(t_{\text{CoFeB}} \rho_{\text{CoFeB}} + t_{\text{Au}} \rho_{\text{Au}})}{h_{\text{total}}}. \quad (9)$$

The calculated effective elastic constants for the investigated samples, [CoFeB/Au]₁₅ and [CoFeB/Au]₂₀, are summarized in Table S1.

S2 Dispersion relation for isotropic [CoFeB/Au]_N

Figure S1 shows the dispersion relation for isotropic [CoFeB/Au]_N using the Finite Element Method. The experimental data are shown as black dots, while the simulated dispersion is plotted as solid lines. A noticeable deviation between the experimental data and the simulation is observed.

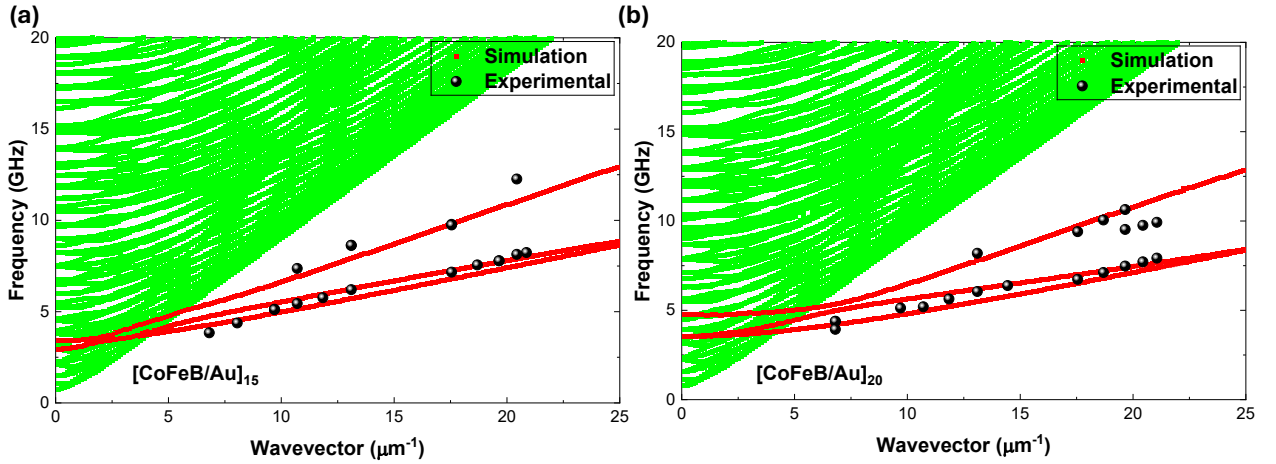


Figure S1: Experimental (symbols) and finite-element-method (FEM) simulated (solid lines) dispersion relations of surface acoustic waves for isotropic samples with (a) $N = 15$ and (b) $N = 20$. The low-frequency red line corresponds to R-SAW, two high-frequency red lines correspond to S-SAWs, and the green region indicates the bulk acoustic continuum of the samples.

S3 Angular dependence of bulk acoustic waves

The Bulk Acoustic Wave (BAW) velocity distribution for Ti, Au, and CoFeB is shown in Fig. S2. Three bulk velocities, quasi-longitudinal (QL), quasi-transverse (QT), and pure transverse (PT), are represented in green, red, and blue lines, respectively, in the (001) plane. The figures S2(a), S2(c), and S2(e) correspond to the materials treated as anisotropic, while Fig. S2(b), S2(d), and S2(f) correspond to the materials treated as isotropic cases.

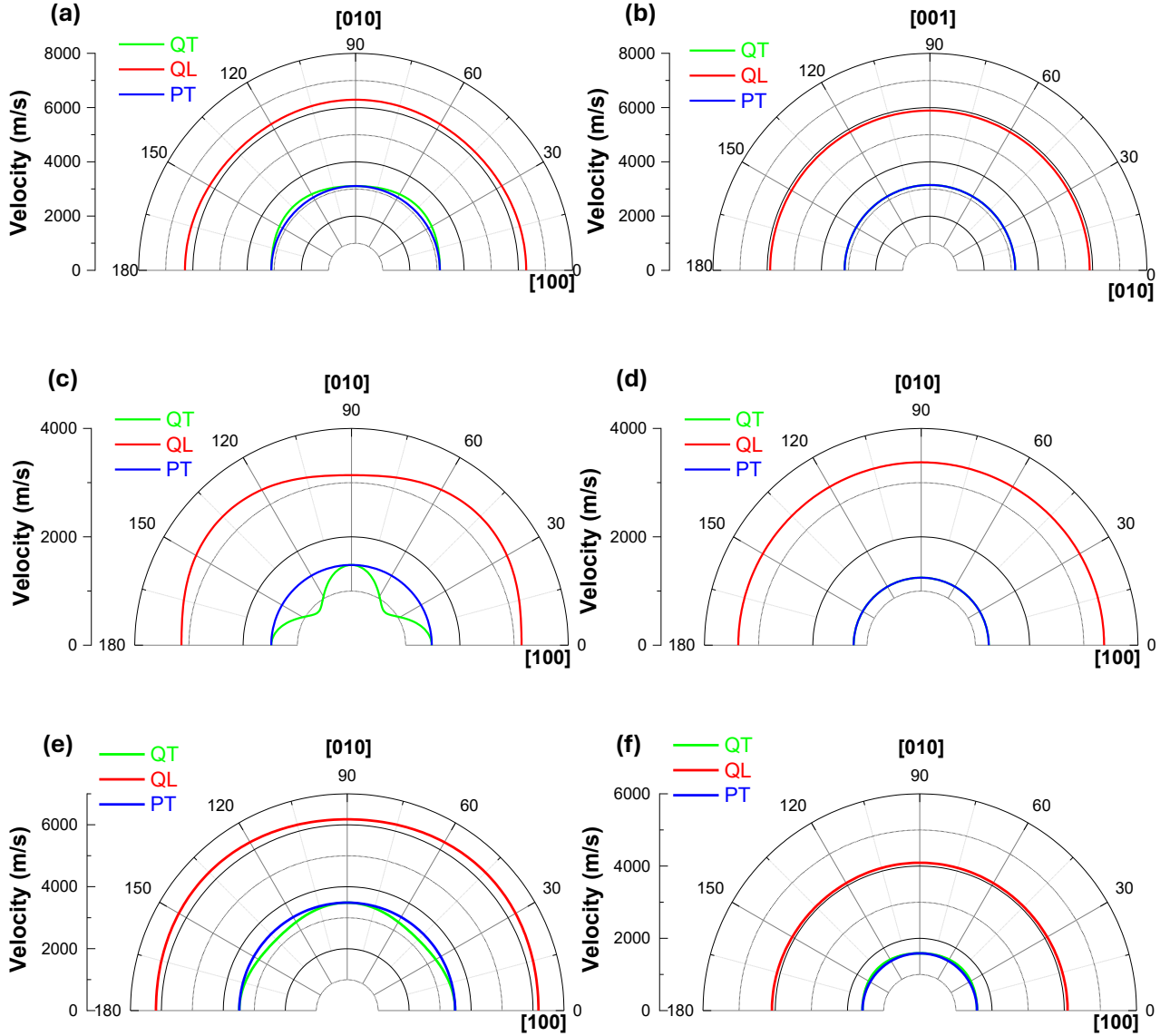


Figure S2: Distributions of angular dependence of bulk acoustic wave (quasi longitudinal (QL, red), quasi transverse (QT, green), and transverse (PT, blue)) velocities in the plane (001) for (a) anisotropic and (b) isotropic titanium, (c) anisotropic and (d) isotropic gold, and (e) anisotropic and (f) isotropic CoFeB.