Engineering magneto-rotational coupling in ferromagnetic nanoelements embedded in elastic substrates

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This study investigates magneto-rotational coupling [1, 2] as a distinct contribution to magnetoelastic interactions. We determine magneto-rotational coupling coefficients that incorporate the shape anisotropy of a ferromagnetic nanoelement in the form of a strip and demonstrate that this contribution can be effectively engineered through geometric modifications, in particular by varying the aspect ratio of the strip cross section [3].

We analyze the magneto-rotational contribution to the magnetoelastic field in a ferromagnetic strip embedded in a nonmagnetic elastic substrate. Surface acoustic waves of both Rayleigh and Love type are considered as sources of the magnetoelastic field. The dependence of the magneto-rotational coupling strength on the direction of the in-plane magnetization is examined, together with its sensitivity to the thickness-to-width ratio of the strip.

For a fixed magnetization direction corresponding to the strongest magnetoelastic coupling, we show that the magneto-rotational contribution exhibits distinct behaviors for different types of acoustic waves. In the case of Love waves, the out-of-plane component of the magnetoelastic field increases monotonically with increasing thickness-to-width ratio, while the in-plane component decreases monotonically. In contrast, for Rayleigh waves only the out-of-plane component contributes, and its magnitude decreases with decreasing thickness-to-width ratio, approaching zero as the cross section becomes square.

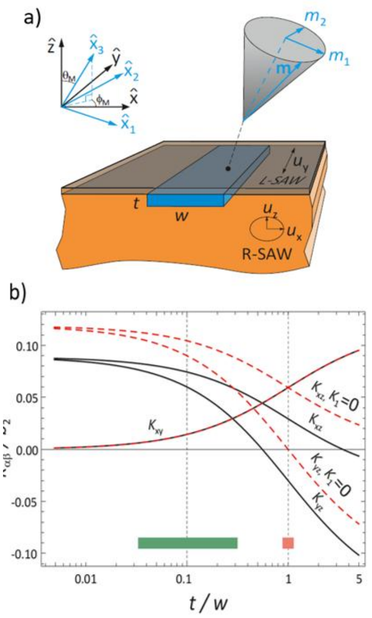

Fig. 1. (a) Magnetoelastic interaction between the fundamental mode of the precessing magnetization in a ferromagnetic strip (blue) and surface acoustic waves (SAW) propagating in a non-magnetic substrate (orange) along the *x*-direction, i.e. perpendicular to the strip. The interaction is not only due to the intrinsic magnetostriction of the ferromagnetic material but also caused by the magnetic anisotropy and related to the magneto-rotation coupling. (b) The coefficients $K_{\alpha\beta}$ for the magneto-rotation coupling as a function of the aspect ratio thickness/width (*t/w*) of the ferromagnetic strip. The calculation was performed for surface anisotropy K_s = 1.05 mJ/m2 , saturation magnetization M_s = 1150 kA/m and conventional magneto-elastic constant b_2 = 7×106 MJ/m3. We have fixed the thickness of the strip *t* = 5 nm and varied its width *w*.

This work has received funding from NCN Poland under Grants UMO-2020/39/O/ST5/02110, UMO-2021/43/I/ST3/00550 and support from the Polish National Agency for Academic Exchange Grant No. BPN/PRE/2022/1/00014/U/00001.

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