Bragg-mirror waveguides for magnonics

(complete result)

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Magnonics is a potential solution for reducing energy losses in data processing. A critical component required for the implementation of magnonic circuits is the waveguide. While many studies have been conducted on waveguides, further research on alternative designs is still highly required. In our work, we have designed a magnonic waveguide using the concept of Bragg mirrors to confine and guide the spin waves in a uniform CoFeB layer. The Bragg mirrors for spin waves can be fabricated by applying surface anisotropy in periodic sequences of stripes on the top and bottom surfaces of the layer. This periodic modulation of the surface anisotropy is equivalent to the formation of the pair of 1D magnonic crystals, surrounding the waveguide - wider strips of pristine CoFeB layer – see Fig. 1. The localization inside the waveguide is a consequence of the Bragg scattering of spin waves and the resulting formation of magnonic gaps – see Fig. 2. In order to obtain a satisfactory group velocity of the spin waves propagating along the waveguide, we applied the external field perpendicularly to the axis of the waveguide (i.e. we used Demon/Eshbach geometry) and chose a sufficient thickness of the magnetic layer, trading it for the strength of the periodic modulation of the magnonic crystals (determined by the effective volume anisotropy). It is worth noting that the considered design has important advantages: (i) it is based on a uniform magnetic layer of low damping ferromagnet and requires only the application of the periodic pattern of nonmagnetic material, (ii) it does not exhibit the static demagnetizing field and the presence of edge mode in the waveguide.

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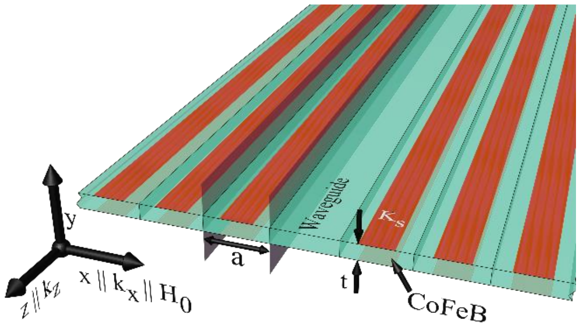

Fig. 1. Scheme of considered structure. A periodically repeated supercell consisting of a = 100 nm wide (*x*-direction) and t = 6 nm thick 43 elementary cells. On the 50% of the top and bottom surfaces of each elementary cell (except the defect) surface anisotropy was applied--see red area. The strength of surface anisotropy was determined by the surface anisotropy constant (K_S=1.05 mJ/m^2). For the sake of symmetry, the defect was placed at the center of the supercell.

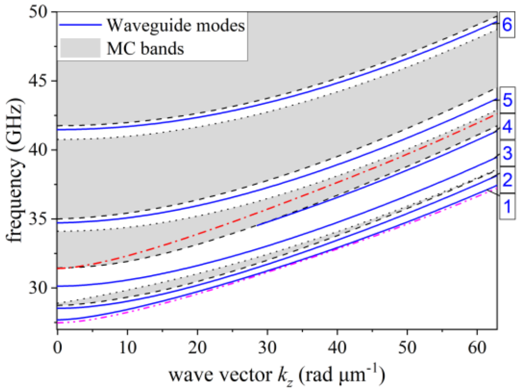

Fig. 2. Dispersion relation obtained for the considered structure. Allowed bands for subsequent waveguide modes (blue color) may propagate in forbidden bands for the magnonic crystal (gray areas). The lowest possible frequency for waveguide mode is defined by FMR frequency for 6 nm thick CoFeB layer (dot-dot-dash magenta line). FMR frequency for a 6 nm thick CoFeB layer with introduced surface anisotropy on both faces (dash-dot red line) divides strongly localized modes 1-4 from less localized higher modes 5-6.