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ABSTRACTS

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Session AD
SPIN WAVES I

AD-06. Surface-acoustic-wave-pumped parametric amplification of forward volume spin waves. *I. Lisenkov*[1,2], J. Davies[3], A. Jander[1] and P. Dhagat[1] *1. Electrical Engineering and Computer Science, Oregon State University, Corvallis, OR; 2. Kotel'nikov Institute for Radioengineering and Electronics, Moscow, Russian Federation; 3. Advanced Technology, NVE Corporation, Bloomington, MN*

Parametric amplification of spin-waves is used to sustain spin-wave amplitudes in magnetic waveguides and for nonlinear signal processing [1]. Here we establish the conditions and calculate the gain for surface-acoustic-wave (SAW) parametric amplification of spin waves in a magnetic waveguide. In contrast to the well-established method of using RF magnetic fields for parametric pumping [2], the symmetry of magnetoelastic interactions allows for the pumping of forward volume spin wave (FVSW) modes. In RF magnetic field pumping, the coupling depends on the ellipticity of precession and vanishes for circular precession. Thus, this method works well for the backward volume spin-waves (BVSW). The application of BVSW faces difficulties: BVSW may decay via the three-magnon process, and the RF field excites not only the desired long wavelength dipolar waves, but also short dipolar-exchange spin-waves, which are not usable in signal processing. FVSW do not suffer from the these problems, but the precession in FVSW is circular, disallowing pumping with magnetic fields. We propose an alternative approach, using magneto-elastic coupling to pump FVSW. A thin film magnetic waveguide is patterned atop a substrate which supports a standing Rayleigh SAW, Fig. 1. The SAW results in a surface strain, which, via magnetostriction, modulates the magnetic anisotropy and couples to the magnetization. For a uniform spin-wave profile the coupling coefficient is: $V \approx \gamma B_1/Ms \int u_{xx}(x)dx/w$ where γ is the gyromagnetic ratio, the integral is taken across the waveguide, $u_{xx}(x)$ is the in-plane strain in the SAW, w is the waveguide width and B_1 is the magnetoelastic constant. Importantly, the coupling, V, is nonzero for circular precession. In Fig. 2 we plot the amplification ratio for FVSW traveling in a waveguide made of NiAlZn-ferrite, a material with a large magnetoelastic coupling (B1= 1.6 MJ/m^3) and low magnetic damping ($\alpha_G = 3.5\ 10^{-3}$) [3], assuming the waveguide width w = 1.1 μm, thickness is 50 nm. The plot demonstrates that it is possible to amplify FVSW with a SAW amplitude of less than 100 pm.

[1] Melkov et al Phys. Rev. E, Vol. 63, 066607 (2001) [2] Schlomann, Green, Milano, J. of Appl. Phys. 31 S386–S395 (1960) [3] Emori et al Adv. Materials 2017 [in press]

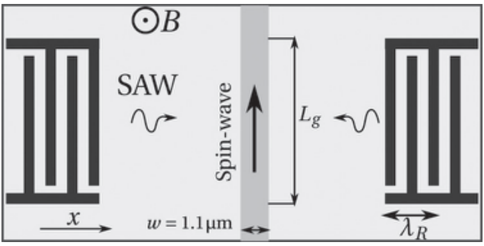

Fig. 1. Principal scheme of SAW parametric pumping

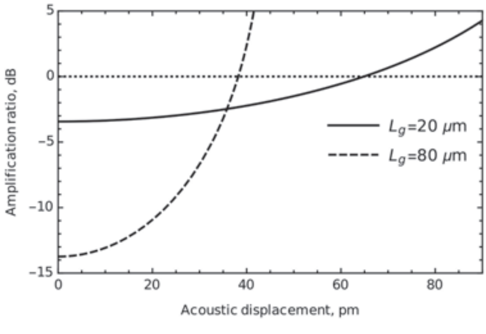

Fig. 2 Amplification ratio of spin-waves by acoustic waves for two values of the pumping region.