The numerical analysis of standing spin wave configurations controlled with a domain wall in nanowires

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1. Introduction

Spin dynamics in nanostructured magnetic system have attracting intense research interests from view point of fundamental physics and practical applications. The geometrically confined standing spin wave resonance (SSWR) is one of the most power efficient excitation modes. Various kinds of SSWR modes have been observed in wires [1], squares [2] and rectangular dots [3], made of in-plane magnetization films. In the present study, the SSWR properties of nanowires with perpendicular anisotropy have been numerically investigated. Especially, the effect of the domain wall (DW) on the SSWR is focused, aiming at the application to a novel memory and logic applications.

2. Numerical model

Fig. 1 (a) presents a designed device structure, consists of a nanowire and inductively coupled conductors for the SWs generators (GE1, GE2) and detector (DE). Material parameters of large perpendicular and low damping ferromagnets, such as MnGa, MnAl, were assumed in the micromagnetic simulations: M_s = 1000 emu/cm^3, H_k = 13 kOe, α = 0.01. Pulsed microwave currents with phase lag $\Delta\phi$ = π and the duration of 930 ps (37.2 ps (=1/(26.9 GHz)) × 25 periods) were assumed to be applied through GE1 and GE2, which excite the 2nd mode SSW along the nanowire. The inductive output waveform when the DW located at the nanowire center is shown as Fig. 1(b).

3. Results and discussions

The maximum amplitude Vout computed for various locations of the DW (x_{DW}) is shown in Fig. 2(a). The significant dependence of the Vout reflects the modification of the SSW configuration due to the DW location, as shown in Fig. 2(b), (c). The DW located under the GE locally suppresses the magnetization precession, reflecting lower Vout, while the influence from the DW located at the nanowire center (node of the SSW) is subtle, reflecting higher Vout. The obtained numerical results demonstrate feasibility of the domain wall location as a state variable of nanowires.

[1] Z. K. Wang, et al., Phys. Rev. Lett., 89, 027201 (2002).
[2] A. Barman, et al., Phys.Rev. B, 69, 174426 (2004).
[3] G. Carlotti, et al., J. Appl. Phys., 117, 17A316 (2015)

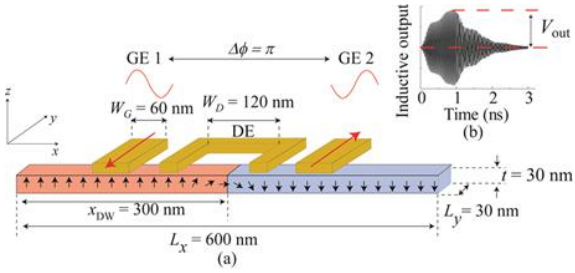

Fig. 1. Schematic of a designed nanowire with DW (a) and the V_{out} waveform (b).

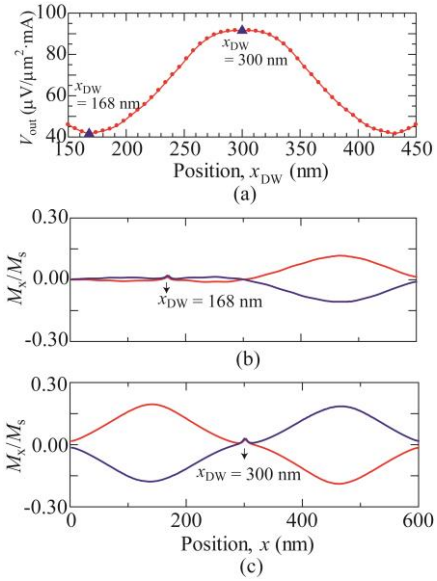

Fig. 2. Dependence of the Vout on the x_{DW} (a), and the comparison of the SSW profile for different DW position; x_{DW} = 168 nm (b) and = 300 nm (c).