Magnetic field dependence of antiferromagnetic domain wall velocity driven by magnetoelectric effect

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Recent development of spintronics enabled us to control antiferromagnetic (AFM) moments/domains. We have been reported that the AFM domain state of the Cr_2O_3 thin film in the Pt/Co/Au/Cr_2O_3/Pt thin film could be controlled by using the magneto-electric (ME) effect including the ME-induced AFM domain wall (AFM-DW) velocity [1]. In this scheme, similar to the ferromagnetic DW motion, it is expected that the effective damping parameter can be evaluated based on the magnetic-field dependence of the AFM-DW velocity which is presented in this work.

Pt(2 nm)/Co(0.5 nm)/Au(0.7 nm)/Cr_2O_3(70 nm)/Pt(20 nm) thin film was prepared by using the DC magnetron sputtering system with the base pressure below 1×10^{-6} Pa. The film was patterned into the micro-dot with the diameter of 30 μm using photolithography and Ar ion milling. The AFM-DW velocity was evaluated based on the magnetic domain observation using the scanning soft X-ray magnetic circular dichroism (XMCD) microscope at BL25SU, SPring-8. The magnetic domain observations were done at remanent state, i.e. μ_0H = 0 T and E = 0 V/m, after the pulsed ME field, $\mu_0 H$ = 2.5, 2.75 and 3 T and E = 43 – 207 MV/m with 10-100 ns pulse width, was applied. The observation temperature was 270 K.

Figure 1 shows the example of the change in the magnetic domain pattern by the pulsed ME field and the pulse-width dependence of the domain wall propagation length. Magnetic domain with the opposite spin direction, which corresponds to the distribution of the exchange bias polarity (interfacial AFM spin) [2], grows by the pulsed ME field. The DW propagation length increases almost linearly with the pulse width, from which we could evaluate the ME-induced AFM-DW velocity. Based on the magnetic field dependence of the AFM-DW velocity, we will discuss the effective damping parameter in the Pt/Co/Au/Cr_2O_3/Pt thin film.

[1] Y. Shiratsuchi *et al*., J. Phys.: Condens. Matter 33, 243001 (2021).

[2] Y. Shiratsuchi *et al*., Appl. Phys. Lett. 113, 242404 (2018).

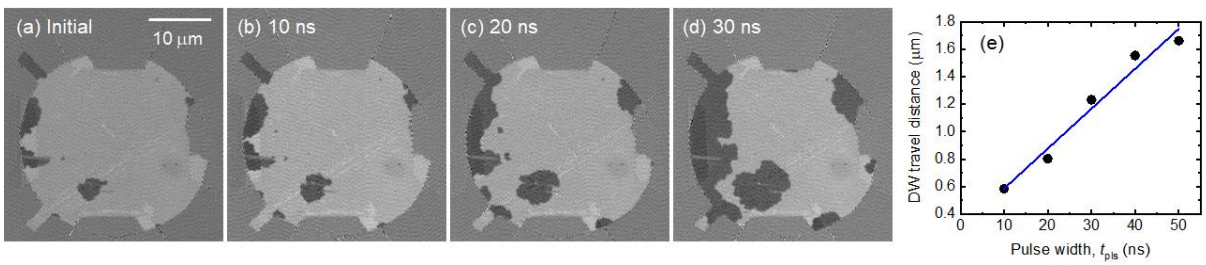

Figure 1 (a)-(d) Changes in magnetic domain pattern after applying pulsed ME field ($\mu_0 H$ = 2.75 T, E = 192 MV/m) with various pulse width (t_{pls}). (e) t_{pls} dependence of DW propagation length.