Ultrafast STT-driven domain wall motion in Mn_4N microstrips

1.Inst. of Appl. Phys., Univ. of Tsukuba, Japan, 2. Univ. Grenoble Alpes, CEA, CNRS, Grenoble INP, INAC, SPINTEC, France, 3. Univ. Grenoble Alpes, CNRS, Institut Néel, France, 4. Inst. for Mater. Sci., Kiel University, Germany, ○T. Gushi[1,2*], L. Vila[2], J. P. Attané[2], O. Fruchart[2], A. Marty[2], S. Pizzini[3], J. Vogel[3], M. Klug[4], J. Pena-Garcia[3], A. Anzai[1], T. Komori[1] and T. Suemasu[1]

E-mail: bk201011030@s.bk.tsukuba.ac.jp

[Introduction] Ferromagnetic nitrides have been attracting attention as new candidates for rare-earth free spintronic materials. Indeed, ferrimagnetic Mn_4N combines small M_S of 80 kA/m with high perpendicular anisotropy with K_u around 10^5 J/m^3 [1]. These properties allow foreseen high spin-transfer torque (STT) efficiency and narrow domain walls (DWs), very well suited for current induced domain wall motion (CIDWM) devices. We have already shown the prominent properties of DW in Mn_4N films with millimeter-sized domains and fast CIDWM over 240 m/s. In this work, we present the real potential of Mn_4N as a candidate for CIDWM application with extremely high DW speed, reaching almost 1 km/s.

[Experiment] A 10-nm-thick Mn_4N film was grown on a $SrTiO_3$(001) substrate by the molecular beam epitaxy, followed by fabrication of 1 or 2-μm-wide strips by EB-lithography and Ar-ion-milling. Each sample consists of 20 wires with two larger electrodes acting as nucleation pads. After the formation of DWs by a pulsed field, nominal 1-ns-long current pulses were injected. The displacement Δx was measured by Kerr microscopy. The DW speed v_{DW} was calculated from Δx divided by the measured length of the current pulse.

[Result and discussion] Figure 1 shows a typical differential Kerr image after pulse injection. The trajectory of DW, white area in the figure, was converted to Δx. Figure 2 shows the current density dependence of v_{DW} for both 1 and 2 μm strips. The threshold current density was 0.3× TA/m^2. The maximum average v_{DW} reached over 900 m/s with 1.3 and 1.5 TA/m^2 for each width. This velocity is one of the highest value reported, even compared with SOT-assisted systems. We estimated the amplitude of STT, $u=jP\mu_B/eM_S$ [2], and obtained 1.36 km/s at maximum where P=1, agreeing with ultrafast DW motion driven by classical STT. In this presentation, we will also discuss the results of micromagnetic simulations in our system.

[Acknowledgement] This work was financially supported in part by JSPS (No. 16J02879).

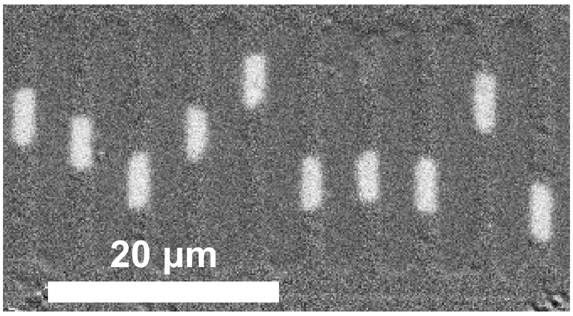

Figure 1 Differential Kerr image of 2-μm-wide strips after DW motion. The white area is the DW displacement.

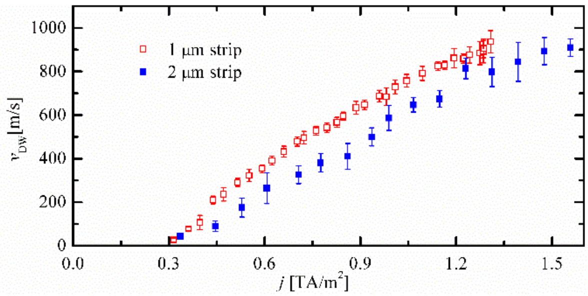

Figure 2 Current density dependence of the DW speed.

[References]

[1] K. Ito *et al.*, AIP Advances **6**, 056201 (2016).
[2] A. Thiaville *et al.*, Europhys. Lett., **69**, 990 (2005).