Magnetic properties of perpendicularly magnetized Mn_4N thin films deposited on MgO and STO substrates, for current-induced domain-wall motion devices

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[**Introduction**] We show that ferrimagnetic Mn_4N thin films possess a high potential for the development of devices based on current-induced domain wall motion (CIDWM). Composed only of abundant elements, this system has a high perpendicular anisotropy ($\mu_0 H_K$ about 3 T), and a very small $\mu_0 M_S$ (0.14 T) [1,2]. Therefore, Mn_4N is an attracting candidate to achieve fast CIDWM at low current densities.

[Experiment] We evaluate and compare magnetic properties of Mn_4N films grown on MgO or $SrTiO_3$ (STO) substrates. Single crystalline Mn_4N films have been deposited at 450 °C using molecular beam epitaxy [2], with a 3-nm-thick SiO_2 cap. We report Magneto-transport, and magnetic configuration observed using magnetic force microscopy (MFM) and magneto-optical Kerr microscopy.

[**Result and discussion**] Figure 1 shows the hysteresis loops (minor for B) of anomalous Hall resistivity ρ_{AHE} for each Mn_4N film. Concerning films on MgO, the thicker one (A) has better properties than the thinner one (B), with a lower coercivity and a higher remanence. Sample C on STO, exhibits an even smaller coercivity, a perfect remanence and a sharper magnetization switching.

Figures 2 are domain structures of Mn_4N films after demagnetization. Samples on MgO show sub-µm domains, much smaller than what would be expected at equilibrium from the small M_S and large K_u of Mn_4N. In contrast, the sample on STO has mm-size domains. In addition, the smoothness of the DWs in the latter indicates that there are few DW pinning sites, consistent with the sharp magnetization switching. We attribute the differences between the two substrates to the large misfit between MgO(100) and Mn_4N(100) (−8%), leading to defects that pin DWs. Because of the strain relaxation in the vicinity of the interface, the importance of these defect is more prominent in the thinner film on MgO.

By using STO substrates instead of MgO, we greatly improved the magnetic properties of the Mn_4N layer. With a moderate coercivity (given M_s), macroscopic domains, smooth DWs, and a square hysteresis loop, Mn_4N/STO layers have a great potential for current-induced DW motion.

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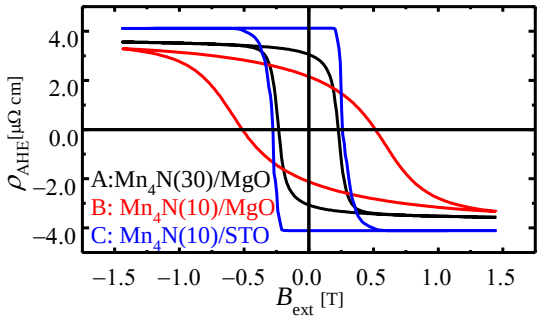

Figure 1: Hysteresis loops obtained by anomalous Hall effect.

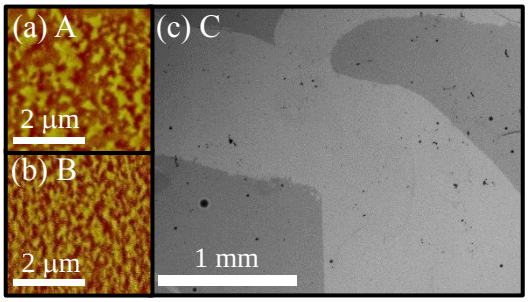

Figure 2: MFM images of the domain structure after demagnetization for samples A (a) and B (b). (c) Magneto-optical Kerr microscopy image for sample C.

[**References**]

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[2] Y. Yasutomi *et. al.* J. Appl. Phys. **115**, 17A935 (2014).