

Mapping of Magnetic Metastable States in Synthetic Antiferro- and Ferrimagnets with Perpendicular Magnetic Anisotropy

Ruslan Salikhov, Fabian Samad, Leopold Koch, Benny Böhm, and Olav Hellwig

Magnetic multilayers (MLs) with perpendicular magnetic anisotropy (PMA), such as Co/Pt or Co/Pd, are the host materials for a variety of metastable magnetic configurations, e.g. aligned or labyrinth stripe domains, bubble domains and their mixtures. The magnetic morphology at remanence mostly depends on the specific demagnetization routine using an external magnetic field [1], whereas the characteristic size of the magnetic objects (domain period or bubble radius) is mostly determined by the design parameters of the magnetic MLs (e.g. the thickness of Co layer, periodicity and the number of repeats X) [1,2]. Interleaving the Co/Pt (or Co/Pd) blocks by Ru or Ir layers, which promote antiferromagnetic (AF) interlayer coupling between PMA ML blocks, results in a class of artificial magnetic structures, known as synthetic antiferromagnets (SAFs) with PMA. The AF interlayer exchange energy alters the typical energy balance, thus modifying the morphology and characteristic size of magnetic domain states in PMA SAFs [1]. Stabilisation of magnetic bubble domain states in SAFs is of particular practical interest [3], whereas other new magnetic configurations are of interest for fundamental research. Here we present the mapping of magnetic states in SAFs for different demagnetization protocols and ML parameters by means of monitoring the remanent magnetization M_R during the AC or DC demagnetization process itself and performing magnetic force microscopy (MFM) imaging at the intermediate states of interest (Fig. 1). The aligned stripe domain state is characterised by almost zero M_R , whereas bubble domains [4] and mixed states (Fig. 1) manifest themselves by an enhanced M_R . The magnetic states for SAFs with tuneable parameters such as Co thickness and repetition number X will be presented. We will also discuss the magnetic behaviour in synthetic ferrimagnets, where the two ML block sub-lattices have different magnetic moments.

- [1] O. Hellwig, A. Berger, J. B. Kortright, JMMM, Vol. 319, p.13-55 (2007)
- [2] I. Lemesh, F. Büttner, G. S. D. Beach, Phys. Rev. B, Vol. 95, p.174423 (2017)
- [3] K. Chesnel, A. S. Westover, C. Richards, Phys. Rev. B, Vol. 98, p.224404 (2018)
- [4] A. Hubert, R. Schäfer, Magnetic Domains, Springer Berlin (2009)

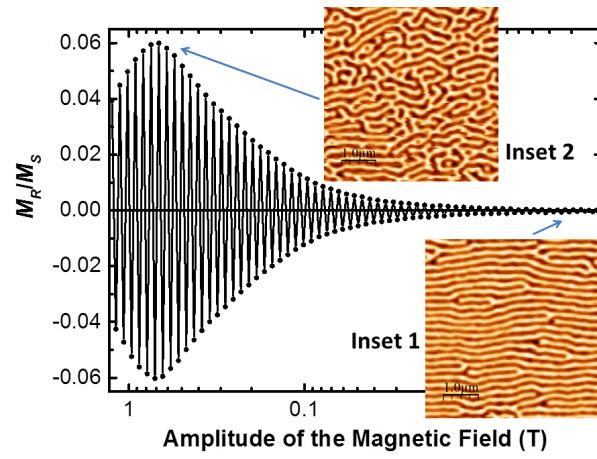


Fig. 1 M_R normalised to saturation magnetization M_S for different field amplitudes applied during the AC demagnetization process for the $\{[\text{Co}(0.4 \text{ nm})/\text{Pt}(0.7 \text{ nm})]_8\text{Co}(0.4 \text{ nm})\}/\text{Ru}(0.9 \text{ nm})\}_{18}$ PMA SAFs. The inset 1 shows an MFM image of aligned stripe domains. The inset 2 presents the mixed labyrinth and bubble domain states with largest M_R .