NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Title : Generation of skyrmionic entities in Fe/Gd multilayers with easy plane magnetic anisotropy

General Scope :

Magnetic skyrmions, localized and topologically non-trivial entities, are extensively investigated due to their solitonic nature. They may be created in appropriated conditions in terms of temperature (close to RT) and operating magnetic fields (from a few hundreds of mT down to zero field). In most experimental studies reported in the literature for thin multilayers, the observation of skyrmions requires an easy axis of magnetization perpendicular to the plane of the layers, *i.e.* perpendicular magnetic anisotropy (PMA). Unfortunately, the latter often implies low material thicknesses (for strong surface anisotropies) and high Gilbert damping factor, leading to low thermal stability of skyrmions and large current densities for their motion. These characteristics are serious obstacles for applications in spintronics. Ferrimagnetic multilayers with planar magnetization may, as well as low Gilbert damping factor, present an alternative within a very different paradigm. Indeed, our RT Lorentz Transmission Electron Microscopy (LTEM) measurements on a planar $[Fe/Gd]_{N=60}$ multilayer with very thin thicknesses have evidenced 110 nm broad skyrmion-like objects as seen in **Fig 1(a)**. The magnetic loops at RT [see **Fig. 1(b)**] establish an in-plane magnetic anisotropy for the stack. Here, a particular protocol of applied magnetic fields and operating temperature is necessary for creating such particular magnetic objects.

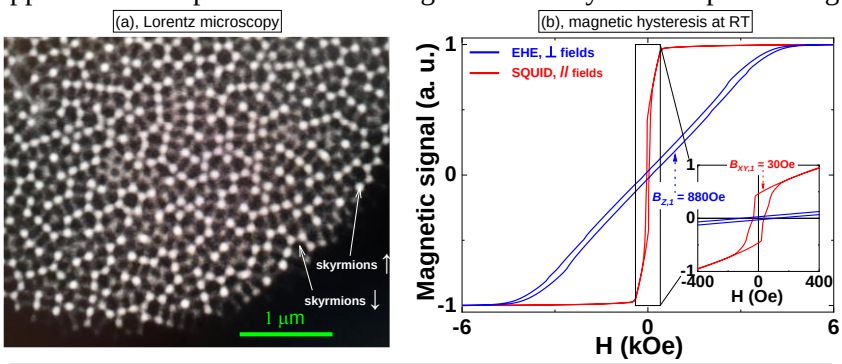

Figure 1 (a) : LTEM at RT for the $[Fe/Gd]_{N=60}$ multilayer. (b). Magnetic loops at RT of the same stack for planar (// fields, red curve) and perpendicular (⊥ fields, blue curve) magnetic fields.

Research topic and facilities available :

The internship will elaborate ferrimagnetic multilayers by magnetron sputtering, and characterize the magnetic properties mainly by hall effects in the (30-600)°C range of the temperature (home-made set-up), coupled to LTEM investigations. Intensive X-Ray Reflectivity measurements will be also investigated for analyzing the structural state of the multilayer. To carry out this work, the trainee will have also access to the NanoFab cleanroom tools for the lithography techniques.

Reference: Marisel Di Pietro Martínez et al., Phys. Rev. B **107**, 094425 (2023)

Possible collaboration and networking : This work will be realized in the Surfaces Interfaces Nanostructures group (SIN,CNRS/Institut Néel) in collaboration with the SPINTEC laboratory for Lorentz Transmission Electron Microscopy measurements.

Possible extension as a PhD : YES

Required skills: Master 2 (or equivalent) with good knowledge in solid state physics.

Starting date : March 2024 (flexible)

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More information : https://neel.cnrs.fr/equipes-poles-et-services/surfaces-interfaces-et-nanostructures-sin