Creating 3D-Magnetic Textures in Synthetic Antiferromagnets by Focused Ion Beam Irradiation

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The DMI assisted emergence of 3D-magnetic textures in general and magnetic skyrmions, in particular, were hitherto typically observed in bulk B20-materials at low temperatures or in ferromagnetic multilayers at room temperature [1]. In contrast, we used a synthetic antiferromagnet (AF) [2] as a platform, consisting of perpendicular anisotropy Co/Pt-multilayers, AF coupled via Ru interlayers. Such a system provides the striking benefits of an absence of stray fields as well as high domain wall velocities [3], making it interesting for possible future data storage applications. The ground state energy balance was previously shown [2] to depend on the ratio of dipolar energy and AF exchange energy, which increases with the Co layer thickness or Co/Pt-repetition number, thus yielding a phase transition to a ferromagnetic stripe domain state. Here, differently, we use focused He^+ ion beam irradiation with different fluences and energies, to modify the local energetical interplay between dipolar and AF interlayer exchange energy. Thus, we were able to create a variety of laterally coexisting magnetic phases (see Fig. 1) and 3D-magnetic textures in different confinements. Detailed investigation of their interactions as well as their magnetic field reversal behavior were performed with in-field high-resolution magnetic force microscopy.

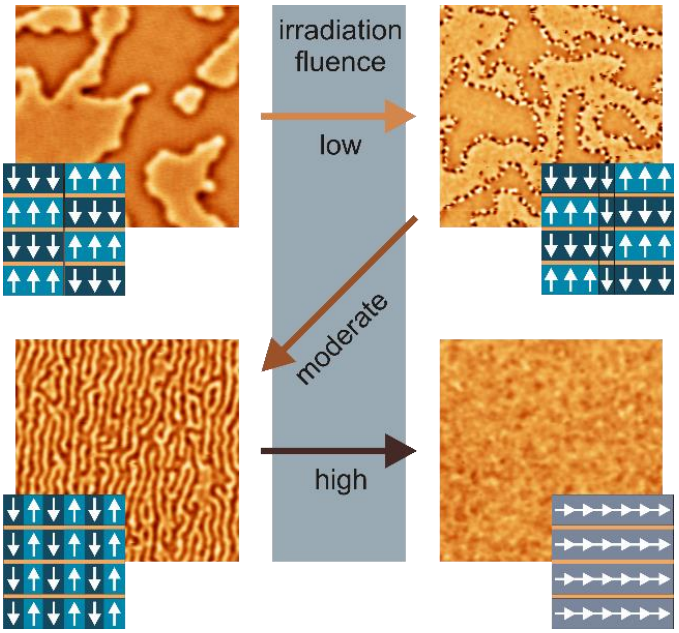

Fig. 1: 5 µm x 5 µm MFM images showing the various types of domain structures observed in He^+-ion irradiated perpendicular AF-coupled $([Co/Pt]_6/Ru)_4$ multilayers, after in-plane demagnetization. In the insets the corresponding spin textures are indicated.

[1] Soumyanarayanan et al., Nat. Mater. 16, 898-904 (2017).
[2] O. Hellwig et al., J. Magn. Magn. Mater. 319, 13-55 (2007).
[3] Yang et al., Nat. Nanotechnol. 10, 221-226 (2015).