Neutron Scattering on Magnetic Multilayers Deposited onto highly ordered nanosphere arrays

Asmaa Qdemat[1]*, *Emmanuel Kentzinger[1], Johan Buitenhuis[2], Sabine Pütter[3], Mai Hussein Hamed[4], Connie Bednarski-Meinke[1], Oleg Petracic,[1,5], Ulrich Rücker[1], and Thomas Brückel[1]*

[1] *Jülich Centre for Neutron Science JCNS-2, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany.*

[2] *Institute for Biological Information Processing, Biomacromolecular Systems and Processes (IBI-4), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany*

[3] *Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, 85747 Garching Germany*

[4] *Faculty of Science, Helwan University, 11795 Cairo, Egypt*

[5] *Heinrich-Heine-University Düsseldorf, Faculty of Mathematics and Natural Sciences, 40225 Düsseldorf, Germany*

Grazing Incidence Small Angle Neutron Scattering (GISANS) and Polarized Neutron Reflectivity (PNR) are employed in this study to investigate the structural and magnetic properties of magnetic multilayers deposited onto highly ordered nanosphere arrays. The multilayers, composed of (Co/Pd) multilayers with different numbers of repeats, were deposited using Molecular Beam Epitaxy (MBE) on a flat silicon (Si) substrate and on densely packed two-dimensional arrays of silica nanospheres with diameters of 50 nm and 200 nm, formed using an improved drop-casting method [1].

The use of highly ordered nanosphere arrays as substrates introduces a periodic nanostructure that significantly modifies the morphology and magnetic behavior of the multilayers. GISANS provides detailed insights into the lateral structural organization, revealing pronounced periodic ordering influenced by the underlying nanospheres. This lateral order affects the magnetic domain configuration and anisotropy. PNR offers depth profiles, showing increased interfacial roughness and altered magnetic coupling between layers due to the nanosphere-induced topography.

The findings demonstrate that highly ordered nanosphere arrays enhance interfacial roughness, alter magnetization reversal processes, and induce spatial variations in magnetic anisotropy, leading to modified magnetic domain structures. These results highlight the potential of using highly ordered nanosphere arrays to engineer magnetic materials with tailored properties for specific applications. This study advances the understanding of magnetism in curved nanostructured systems and paves the way for designing advanced magnetic materials with optimized functionalities.

References

[1] A. Qdemat, et.al., RSC Adv., 10, 2020.