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Shaping nanoscale magnetic domain memory in exchange-coupled [Co/Pd]IrMn thin films by field cooling

Magnetic nanostructures, such as magnetic domains in perpendicular thin ferromagnetic layers, draw an increasing attention for their potential applications in nanotechnologies. Magnetic domain memory (MDM), i.e. the ability for the domain pattern to retrieve its exact same spatial configuration through field cycling, can be particularly useful in magnetic recording technologies. Here, author will show how x-ray synchrotron tools can uniquely probe the behavior of these magnetic systems at the nanoscale. More particularly, author will review the technique of coherent x-ray magnetic scattering (CXRMS) and how it can be used to measure MDM in thin ferromagnetic films, as illustrated in Figure 1. Because illuminating a magnetic pattern with coherent X-rays produces a speckle scattering pattern that is a unique fingerprint of the magnetic domain configuration, cross-correlating such speckle patterns provides a way to measure MDM. Author will present results on [Co/Pd]IrMn exchange bias thin films that exhibit strong MDM (above 95%) when cooled down below their blocking temperature. By mapping the correlation as function of magnetic field, author will show how the behavior of MDM depends on magnetic history and cooling field. We will see that, when zero-field cooled, the MDM reaches its maximum value in the coercive region of the magnetization cycle. We will also see that MDM is fairly robust through field cycling and through heating, all the way up to the blocking temperature. Finally, author will show how MDM can be fully controlled by adjusting the magnitude of the cooling field: if the film is cooled down under no or moderate field, MDM stays strong and robust throughout the entire magnetization loop; if the film is cooled with under a strong, near saturating field, MDM is essentially lost.

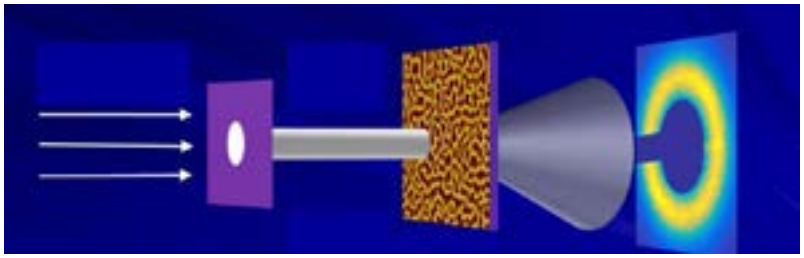

Figure 1: Sketch of the coherent x -ray scattering experiment carried on out ferromagnetic thin films exhibiting domains.

Recent Publications

1. K Chesnel et al. (2008) Magnetic memory in ferromagnetic thin films via exchange coupling Physical Review B 78:132409.
2. K Chesnel et al. (2011) Oscillating spatial dependence of domain memory in ferromagnetic films mapped via x-ray speckle correlation. Physical Review B 83:054436.
3. K Chesnel et al. (2013) Field mapping and temperature dependence of magnetic domain memory induced by exchange couplings. New Journal of Physics 15:023016.
4. K Chesnel et al. (2016) Shaping nanoscale magnetic domain memory in exchange- coupled ferromagnets by field cooling. Nature Communications 7:11648.

Biography

Karine Chesnel received her PhD in Physics in 2002 at the University Joseph Fourier in Grenoble France. She is currently working an Associate Professor in the Department of Physics and Astronomy at Brigham Young University. Her research focuses on nanomagnetism, the study of magnetic properties at the nanoscale. Materials she has been investigated include ferromagnetic thin films with exchange bias, and superparamagnetic nanoparticles. She has published about 40 papers on these topics including a book chapter on magnetic domain memory.

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