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Imaging magnetic relaxation with elemental resolution in hard-soft-hard trilayered films

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Abstract – We report on the use of Scanning Transmission X-Ray Microscopy (STXM) to follow the thermally activated magnetization reversal of Co-Ni trilayers. The microscope allowed rapidly varying the photons energy, which made possible to quasi-simultaneously observe with elemental resolution the relaxation of the samples. We conclude that i) during both the field and the thermally activated reversals the Co and Ni layers switch simultaneously, ii) the thermally activated reversal proceeds from the positive to the negative saturation through non-reproducible, sub-micron scale magnetization configurations and iii) during the relaxation the magnetization varies in association to very rapid transitions between the intermediate configurations.

The use in different devices of magnetic nanostructured films brings about the need of achieving an adequate control of their field and thermally activated magnetization reversal processes. That control requires the identification of the involved local and global reversal mechanisms, which in the most general case result from a compromise between the intrinsic properties and the size, shape and interactions related effects. In this context it seems particularly relevant the phenomenology of the reversal liked to interfacial exchange [1].

In order to study that phenomenology down to the spatial scale of the hundreds of nm we have prepared by using Pulsed Laser Ablation Deposition (PLAD) under UHV conditions Si/Co(50 nm)/Ni(10 nm)/Co(50 nm) trilayers. Those films had Co and Ni thicknesses above and below the Co and Ni exchange correlation lengths, respectively. The relaxation was followed by means of a Scanning Transmission X-Ray Microscope (STXM, 11.0.2 line at the Advanced Light Source, Berkeley Lab). That microscope is characterized by a spatial resolution of the order of 50 nm, well suited for the study of the sub-micron scale phenomenology and by the possibility of rapidly varying the photons energy which for relaxation runs of 10^3 s allows to quasi-simultaneously observe the relaxation of Co and Ni.

From the images taken during both the field and the thermally induced magnetization reversals we concluded that the switching of the Co and Ni layers occurred at once, which evidenced the presence of interfacial exchange coupling (due to the very different Co and Ni anisotropies and the fact that the thickness of the Ni layer was below the Ni exchange correlation length if that interfacial coupling were absent the layers should reversed at substantially different fields). In what concerns the thermal relaxation, imaging of the process revealed that it occurred through very rapid transitions (of the coalescence-propagation type) between magnetization configurations that seemed to be far from equilibrium. Those intermediate configurations were not reproducible in different relaxation runs which suggested that they could be only weakly coupled to defects.

References

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