Using Soft X-Rays to Study Domain Correlations in Co/Cu Multilayers

S. Stadler (Naval Research Lab), Y. U. Idzerda (Montana State University) and J. Borchers (NIST)

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Introduction: Giant magnetoresistance (GMR) is a phenomenon that is exploited in many useful devices such as magnetoresistive read heads in computer hard drives and magnetic sensors. It has been observed that the resistance of a GMR multilayer structure is at its maximum in its as-grown state, i.e., before any magnetic fields are applied to it. This phenomenon has drawn attention since, in understanding it, we might acquire significant insight into the physics of GMR and spin-polarized interfaces.[1]

Recently, a study which combined polarized neutron reflectivity (PNR) data with scanning electron microscopy with polarization analysis (SEMPA) revealed the mechanism for the increased resistance of the as-grown multilayers: enhanced antiferromagnetic (AF) interlayer correlation of magnetic domains across the non magnetic spacer layers present in the as-grown structure. [2] The high resistance state of a GMR device occurs when the layers are antiferromagnetically aligned. In the as-grown state, the antiferromagnetic alignment is maximized; this configuration cannot be recovered by annealing and field cycling, or any other known method.

In the neutron scattering study, evidence of the columnar-like antiferromagnetic correlation was evident in the appearance of half-order reflection peaks. These peaks disappeared and never resurfaced after the magnetic field was applied. In this study, we attempt to apply a technique that is the soft-x-ray analogue to the PNR experiment: soft x-ray resonant magnetic scattering (SXRMS). In these measurements one is able to observe half-order peaks due to AF correlation and their disappearance after the field is applied. The advantage in SXRMS over PNR, is that, in the former technique, we can observe the *dynamic* effect of applying the field, e.g., performing q_x and q_z scans as a function of applied magnetic field.

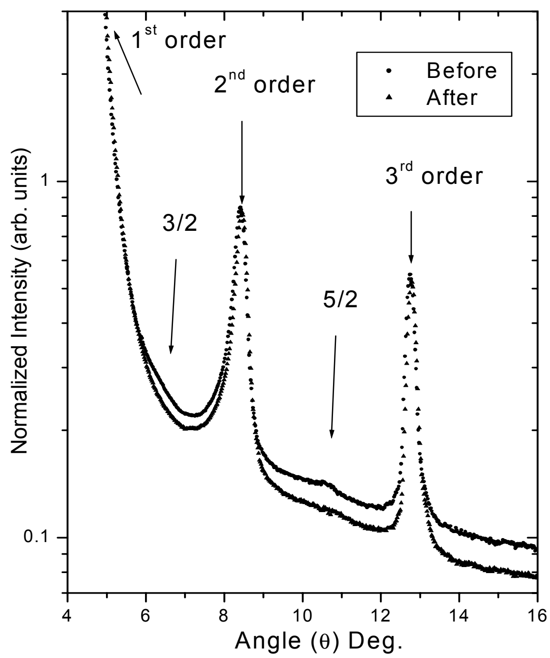

Figure 1. θ-2θ scans before and after a saturating field was applied.

Methods and Materials: In this study, we used the SXRMS technique and performed the measurements in the recently commissioned scattering chamber at beamline U4B. In the case of circularly polarized light, one takes advantage of the dichroic effect intrinsic to the $L_{2,3}$ edges of magnetic transition metals. We conducted scattering experiments on a $[Co(6nm)|Cu(6nm)]_{20}$ multilayer which was the sputter-grown "twin" to the sample used in [2]. With the circularly polarized photons tuned close to the Co L_3 edge at E=779.5 eV, we conducted θ-2θ scans before and after the sample was exposed to a saturating field.

Results: In Fig. 1, half-order peaks appear in the pre-exposed data, and disappear after the field is applied. This indicates that AF correlation between layers is destroyed once the field is applied and directly verifies the PNR study. This study demonstrates the consistency between PNR and SXRS.

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References:

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