X-Ray Reflectivity Analysis of GMR Materials for Magnetoresistive RAM

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The goal of this work was to determine the feasibility of using XRR to quickly characterize GMR material structures of interest for magnetoresistive RAM. We sought to answer the following questions: Which parameters of interest can be measured with this technique? Can the measurement be made fast enough? Will the underlying metal layers interfere with the measurement? We performed a series of experiments using a Philips X Pert diffractometer with Cu K-alpha radiation, a 1/32 deg. incident beam slit, and detector optics consisting of a parallel plate collimator, a fine slit, and a flat HOPG monochromator. The simulations were done with the Philips GIXA software.

The test structure was NiFe 60Å - Co 10 Å - Cu 30 Å - Co 10 Å - NiFe 20Å - Ta 100 Å deposited on SiO_2. A simplified model, which treats the NiFe-Co-Cu-Co-NiFe stack as a single layer, can be useful for simulating the XRR of these materials. It is a reasonable approximation because the scattering factors for the various layers are similar. We find that this model fits the lower-order fringes ($2\theta<4°$) well, but does not reproduce the correct positions for the higher order fringes. When all of the layers are included in the calculation, the high orders are still difficult to fit, because they are sensitive to several fitting parameters but, with care, the higher order fringes can be reproduced. The inclusion of a top TaO_2 reacted layer is necessary in either model. We systematically varied all of the fitting parameters to understand how sensitive the fit was to each.

If only the total stack parameters are needed, a scan taken in less than one minute and fit with the three-layer model is sufficient. Scans of at least 40 minutes are needed for good fits which include all the layers. Interference from the metal layers in the underlying circuitry was not a problem.

In summary, XRR is a useful and practical technique for fast, accurate characterization of the GMR material studied here. Details of the fit sensitivity to the various parameters will be described.