# Magnetic Reflectivity Study of an Exchange Bias Fe/Cr Double Multilayer

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## Introduction

Exchange anisotropy occurs in many magnetic systems where ferromagnetic-anti-ferromagnetic (FM-AFM) interfaces exist. The most common external manifestation of exchange anisotropy is a shift in the hysteresis loop. Typically, this is induced by growing samples having FM-AFM interfaces in the presence of an external magnetic field, or by cooling the sample through the AFM Néel temperature in an applied field. Exchange anisotropy was first observed by Meiklejohn and Bean[1] in 1956. Over the last four decades, exchange anisotropy has been observed in a wide variety of systems and has become an important ingredient in the design of new magnetic storage devices and magnetic materials for other applications.

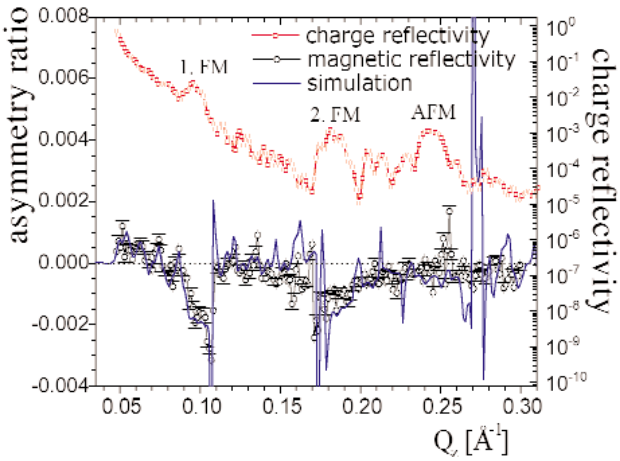


*FIG. 1. Magnetic specular reflectivity data (black circles) shown as the asymmetry ratio ($I_{\uparrow\uparrow}$ - $I_{\uparrow\downarrow}$)/($I_{\uparrow\uparrow}$ + $I_{\uparrow\downarrow}$) with fit (blue line) — the first arrow indicates the helicity of the x-rays, the second the magnetization on the sample — compared with the charge reflectivity curve (red squares).*

On the other hand, our understanding of this phenomenon is still far from complete. Although it was clear from the very beginning that exchange anisotropy is an interfacial effect, the progress in detailed modeling of this phenomenon has been severely hampered by the capabilities in controlling and characterizing the FM-AFM interfaces. For example, it is well known that if one assumes an ideal and fully uncompensated FM-AFM interface, the exchange bias fields calculated using the full interface energy density are typically two orders of magnitude larger than the experimental values. This discrepancy is clearly due to the complex chemical and magnetic structures at the buried FM-AFM interfaces. Hence, the development of new experimental techniques, which are sensitive to magnetic interfaces, is essential.

## Materials and Methods

In this work, we explored the use of circuarly polarized x-rays and specular reflectivity to characterize the magnetization density profile of an exchange bias double multilayer. The exchange bias sample studied in this work consists of a ferromagnetic (FM) Fe/Cr multilayer with 5 periods on top of an antiferromagnetic (AFM) Fe/Cr multilayer with 20 periods.[2] The magnetic circular dichroism at the Fe K-edge was used to provide the magnetic sensitivity of the measurement. A magneto-optic approach developed for visible light scattering was adopted to simulate both the charge and magnetic reflectivity.

## Results

Figure 1 shows the charge reflectivity, the flipping ratios of the specular reflectivity, and the simulations of both. It clearly demonstrates that even though the MCD effect at the transition metal K-edge is very small, it can still be used effectively in these studies. Furthermore, by switching the polarization of the x-rays, we were able to study the magnetization profile as a function of the applied magnetic field, which is essential in the study of exchange bais systems.

## References

[1] W.H. Meiklejohn and C.P. Bean, Phys. Rev. 102, 1413 (1956); Phys. Rev. **105**, 904 (1957).

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