Energy-loss Magnetic Circular Dichroism (EMCD) is a powerful electron microscopy technique capable of extracting quantitative magnetic information from nano-sized features [1–3]. This technique has potential for high impact in research and industry where understanding interfacial magnetism is crucial to the design of nanostructured magnetic materials yet hampered by a lack of reliable small-volume characterization techniques. A key challenge facing further development of the EMCD technique is to extract reliable data from very small volumes of materials with sufficient quality for quantitative analysis. This is especially difficult for metals, as a thin oxide typically forms on the surfaces of the as-prepared lamella during transfer into the transmission electron microscope. In the case of iron, this surface oxide layer may be itself magnetic, potentially complicating the quantification of an EMCD signal from thin regions.

In this study, we investigate variations in the EMCD signal on an iron thin film with a surface oxide layer. The experimental design is depicted in figure 1 and yields a fully convergent beam with a diameter that can be reduced to approximately 1 nm. Under these conditions, we are able to provide a detailed structural and chemical assessment of the surface oxide. Subsequently we explore the consequences of its magnetization as well as how this modifies the detected EMCD signal (see figure 2). We conclude by proposing a method to quantify this effect and distinguish between the EMCD signals from either the underlying metallic film or its surface layer.

References

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Fig. 1: Figure 1 - Illumination conditions for the EMCD experiment. The probe size is limited by the C2 aperture and can be reduced to approximately 1 nm in diameter.

Fig. 2: Figure 2 – ELNES spectra acquired at two detector positions using a probe with a diameter of approximately 1.5 nm. Their difference is an EMCD spectrum.