Scanning soft x-ray magnetic circular dichroism imaging of the changes in magnetic domain structure in Nd-Fe-B sintered magnets throughout the demagnetisation process

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One of the most desirable properties of a permanent magnet is a large coercivity, a property that is directly related to the nucleation of reversed magnetic domains and pinning of the domain walls in the bulk of the magnet. In order to understand the relationship between the coercivity and the generation and evolution of magnetic domains, magnetic domain observations throughout the demagnetisation process are essential. In Nd-Fe-B sintered magnets, it has been shown that fractured surfaces largely maintain bulk coercivities, whilst polished surfaces do not [1]. This makes magnetic domain imaging of the fractured surface under applied magnetic fields highly desirable. So far, many magnetic imaging studies of these materials have been reported. However, conventional magnetic microscopes that can operate under magnetic fields are limited to polished surfaces or transmittable thin films, whilst those that can observe the fractured surface cannot operate under magnetic fields. In order to overcome these limitations, we have developed a scanning soft x-ray magnetic circular dichroism (XMCD) microscope with a spatial resolution of about 100 nm and a focal depth of ±5 μm from the focal point, thereby allowing element specific magnetic domain observations of fractured surfaces. Furthermore, this apparatus is equipped with a superconducting magnet (with a maximum field of ±8 T), which permits investigations of the magnetic field dependence of the magnetic domains. In this talk, I will briefly describe our soft XMCD microscope, and demonstrate its effectiveness by showing some recent results from commercial Nd-Fe-B sintered magnets (see, for example, Fig.1). In particular, I will show and highlight the differences in the magnetisation reversal process in the fractured and polished surfaces of the same sample.

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References

[1] T. Nakamura *et al.*, Appl. Phys. Lett. **105**, 202404 (2014).

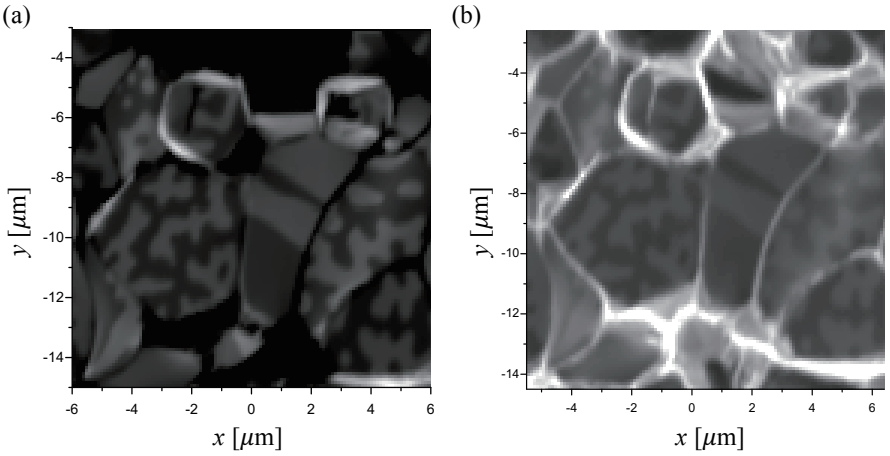

Figure 1: (a) Positive helicity x-ray absorption map of a commercial Nd-Fe-B magnet taken at the Fe L_3-edge. (b) Same as (a) but at the Nd M_4-edge