# Electron magnetic circular dichroism singal acquisition utilizing strong magnetocrsytalline anisotropy

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Electron magnetic circular dichroism (EMCD) is the TEM-EELS counterpart of X-ray magnetic circular dichroism (XMCD), the difference of the $L_{2,3}$ or $M_{4,5}$ inner shell absorption spectra of a magnetic element excited by left and right-handed circularly polarized X-ray [1]. EMCD is superior in spatial resolution, taking advantage of transmission geometry, in contrast to quantitative XMCD measurements mostly applicable to study of sample surface, because the $L_{2,3}$ white-lines of transition metals or $M_{4,5}$ white-lines of rare earth elements are located in the soft X-ray energy region.

In the intrinsic EMCD measurement set-up, with magnetization of a crystalline sample aligned along the optic axis by the magnetic field of the objective lens, symmetric two- or three-beam condition is required [1]. The dichroic signal, $\Delta\sigma$, is acquired as the difference between the two ELNES spectra measured at the two positions, A and B (Figure 1 (1a) and (1b)), equivalent to the left and right-handed circularly polarized X-ray. According to the inversion sum-rule [2], $\Delta\sigma$ is approximately proportional to $(\boldsymbol{q}\times\boldsymbol{q'})\cdot\boldsymbol{M}$, where $\boldsymbol{q}$ and $\boldsymbol{q'}$ are the inelastic scattering vectors subtending the Thale circle from the EELS detector, and $\boldsymbol{M}$ is the magnetization of the sample. One can thus control the magnitude of $\Delta\sigma$ by rotating the direction of $\boldsymbol{M}$ with respect to the optical axis, which has not yet been experimentally exploited.

We measured EMCD signals of $L_{2,3}$ in hcp Co, which is a hard magnet, exhibiting relatively large magnetocrystalline anisotropy. A TEM sample was prepared by electrochemical polishing. Figure 1-a2 and b2 are the spectra collected at the two set-ups shown in Fig. 1-a1 and b1, where the optical axis is nearly parallel and perpendicular to the easy magnetization direction of hcp Co, *i.e.*, [001]. We tilted the sample by approximately $10^{o}$ from the [001] and [100] zone axis to realize the low-order systematic row excitation conditions. The spectral intensities are normalized by the $L_3$ peak collected with the detector position A. The magnetic dichroism is clearly enhanced by the set-up of (a1): $\Delta\sigma$ in (a3) is approximately 2.4 times larger than in (b3), confirming the unsaturated magnetization along the external magnetic field.

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References

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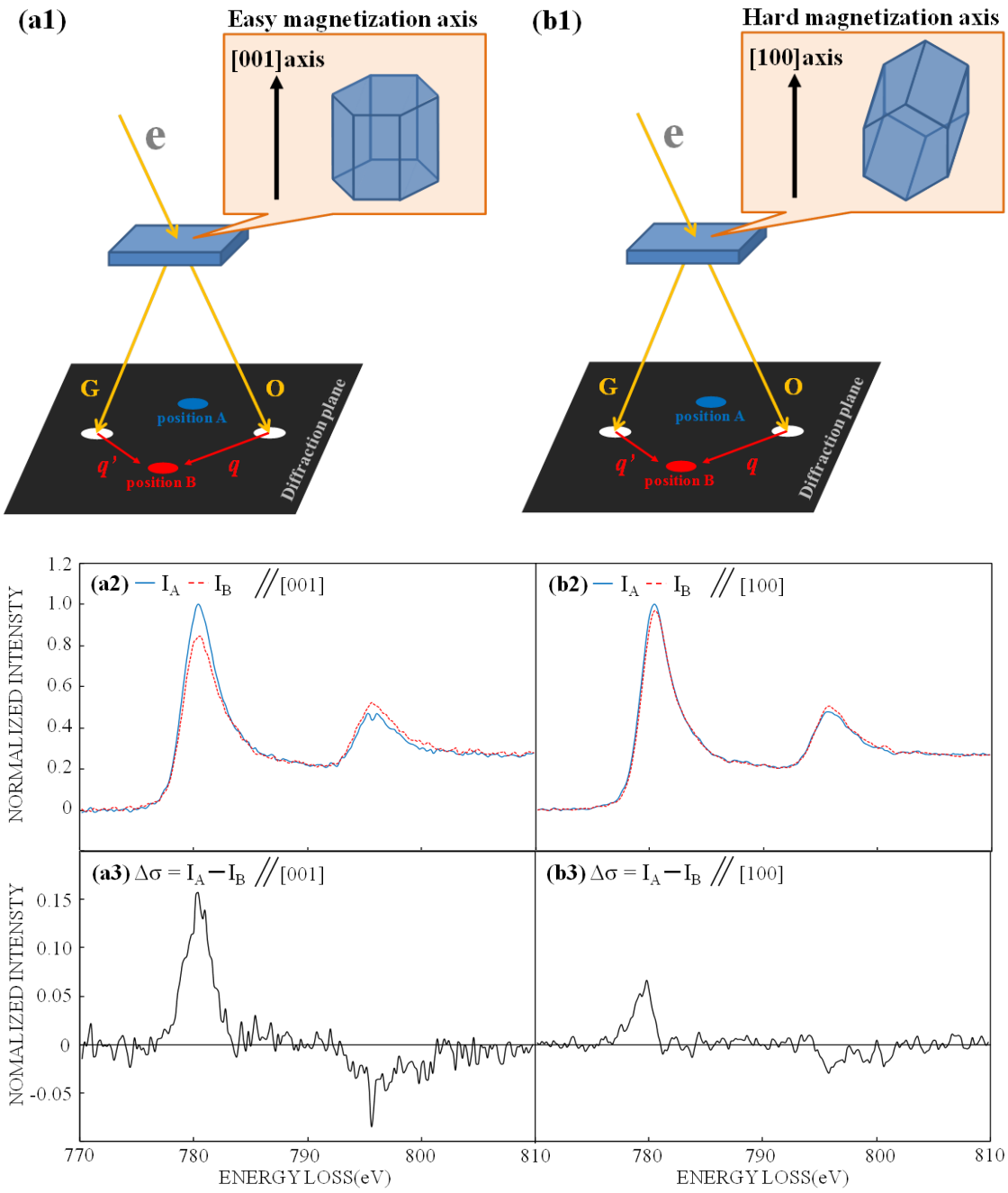


FIG. 1. Schematics of two kinds of measurement set up in the present study (a1, b1), illustrating that optical axis is nearly parallel and perpendicular to easy magnetization axis, respectively. (a2, b2) are corresponding Co-$L_{2,3}$ ELNES are in (a2, b2). Corresponding dichroic signals are (a3, b3).