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Mechanism of Soft X-ray Natural Circular Dichroism

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On the basis of the first successful observation of the soft X-ray natural circular dichroism SXNCD[1], we measured various samples in an attempt to examine the nature of SXNCD for amino acid. Here we report our tentative result for Alanine (Ala).

Thin films of Ala were prepared at Kobe University with vacuum sublimation technique[1]. Thickness of these films was determined to be about 300 nm.

Measurement of absorption spectra and CD spectra of Ala films were carried out at the beamline BL23SU. All spectra were obtained thorough the drain current measurement. Measurements of CD spectra were performed under special sequence in switching of circular polarization and scanning of photon energies as described in Ref. [1] in detail.

Fig. 1 shows obtained SXNCD spectra in the region of nitrogen K-edge together with the ordinary absorption spectrum (ABS). The CD was defined to be CD≡μ_L-μ_R, where, μ designates the absorption coefficient and subscript L and R shows left- and right- circularly polarized light, respectively.

As seen from the figure, several transitions may meet the criterion of the CD spectra; CD peaks of D-Ala should be of the same magnitude with the opposite sign from that of L-Ala. For example, peaks around 406 eV, 407eV and 410 eV seem to be reasonably assigned as candidates of CD peaks. However, a peak around 403 eV is of big contradiction because it appears at energy region with no absorption. This may show that our result shown in Fig. 1 is not perfect because of bad signal to noise ratio.

According to a theoretical calculation with E1M1 model by Plashkevych [2], a strong negative CD peak was suggested to appear at the absorption peak. In fact, a strong peak was observed in our spectrum near the absorption peak (designated as ABS in Fig. 1). This is very encouraging for us.

We are now seeking the possibility to make a calculation based on the E1E2 model. It is very interesting to compare experimental result with E1M1 and E1E2 calculations.

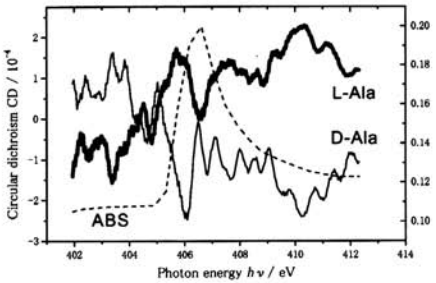

Fig. 1. ABS: Absorption spectrum of Alanine film. L-Ala and D-Ala: Circular dichroism of L- And D-Alanine film, respectively.

References

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Interface effect on the magnetic anisotropy in Co nanoclusters embbeded in a Cu matrix.

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Co and Cu are two inmiscible elements but a metastable solid solution of both can be obtained with the use of ultra-rapid quenching techniques such as melt-spinning. The microstructure of these alloys can be easily modified by thermal treatments that induce the segregation of the minority element (Co) embedded in the copper matrix. As a consequence, different annealing temperature means different microstructure.

Previous studies on Co_5Cu_{95} and $Co_{10}Cu_{90}$ have provided a concise microstructural view at each stage of annealing, between 400 and 650°C. The information gathered from X-ray diffraction, magnetic measurements and EXAFS spectroscopy can be summarized as follows [1]: i) the as-quenched samples contain a majority of Co nanoparticles of 2-3 nm size coexisting with a percentage of Co atoms diluted into the Cu matrix; ii) the thermal treatment induces the segregation of the Co atoms from the Cu matrix, changing the percentage of Co atoms in each phase. For T_{ann}<550°C the diluted percentage diminishes on behalf of the Co nanoparticles. We have related these microstructural studies to the giant magnetoresistance (GMR) response of the samples and concluded that the GMR is strongly influenced by the Co nanoclusters' size, concentration and, especially, interfacial roughness [1].

We have performed a XMCD study on the Co_5Cu_{95} system. The XMCD has been monitored at the beamline BL25SU of the SPring8. Spectra were recorded at 30 K on as-quenched and annealed samples in total electron yield mode. Co $L_{2,3}$ and Cu $L_{2,3}$–XMCD spectra were recorded under an applied magnetic field of 10 kOe. Before the XMCD measurements all the samples were ion-bombarded during 1 hour in order to clean their surface and improve the X-ray penetration.

The Co dichroism signal depends on annealing temperature (see Figure 1) due to the changes in size and concentration of Co nanoparticles. At the same time, we observe an important Cu dichroism signal affected by the size and the interface of the Co particles.

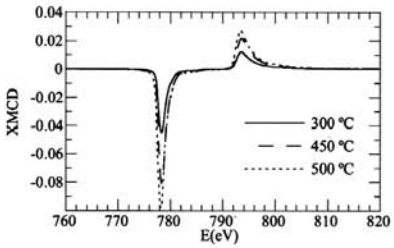

Fig. 1: Co $L_{2,3}$-edges XMCD spectra of Co_5Cu_{95} samples annealed at 300, 450 and 500°C.

We have applied the so-called XMCD sum-rules to get direct information on the modification of the orbital and spin magnetic moment of the Co clusters as both the number of Co nanoclusters and their size increase due to the thermal treatment. Our results indicate that the orbital and spin moments of the Co atoms increase with the annealing treatment. In this way we shall obtain information, at a microscopic level, of how the magnetic anisotropy is affected by the particle size (and therefore by surface conditions) and by the interface disorder.

[1] A. García Prieto et al., Phys. Rev. B **67** (2003) 224415; M.L. Fdez-Gubieda et al., Europhys. Lett. **59** (2002) 855.