

Effect of Surface Chemisorption on the Spin Reorientation Transition in Magnetic Ultrathin Fe Film on Ag(001)

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We have investigated the effect of surface chemisorption of O₂, NO and H₂ on the spin reorientation transitions in magnetic ultrathin Fe films on Ag(001) by means of the polar and longitudinal magneto-optical Kerr effect (MOKE) and X-ray magnetic circular dichroism (XMCD) measurements. Fe was deposited on clean and ordered Ag(001) in ultrahigh vacuum at ~100 K, and the surfaces were dosed with gases at the same temperature. Fe *L*_{III,II}-edge XMCD was taken at BL4B.

Figure 1 shows the remanent magnetization and coercive field of Fe/Ag(001) along the surface normal before and after each gas adsorption, examined by polar MOKE. It is found that adsorption of O₂ and NO induces the shift of the critical thickness for the spin reorientation transitions to a thinner side from 3.5 ML to 2.2-2.5 ML, together with the suppression of the remanent magnetization and the coercive field of the Fe film. This implies destabilization of the perpendicular magnetic anisotropy. On the other hand,

H₂ adsorption is found not to change the magnetic anisotropy as shown in Fig. 1, though the enhancement of the coercive field is observed.

The sum-rule analysis of Fe *L*_{III,II}-edge XMCD shown in Fig. 2 reveals that although both the spin and orbital magnetic moments along the surface normal are noticeably reduced upon O₂ and NO adsorption, the reduction of the orbital magnetic moments are more significant. This indicates that the destabilization of the perpendicular magnetic anisotropy upon chemisorption of O₂ and NO originates from the change of the spin-orbit interaction at the surface.

The present finding that perpendicular magnetic anisotropy is destabilized by O and NO adsorption is in good contrast to the other systems of CO,NO/Co/Pd(111) and CO,NO,H₂O/Ni/Cu(001), where perpendicular magnetic anisotropy is stabilized. These differences can be ascribed to different adsorption fashions; on Fe/Ag(001) the O and NO adsorbates are rather embedded on the topmost Fe layer, while on Co/Pd(111) and Ni/Cu(001) the adsorbates are located above the topmost metal layers. The latter case cannot induce a noticeable reduction of the out-of-plane orbital magnetic moments.

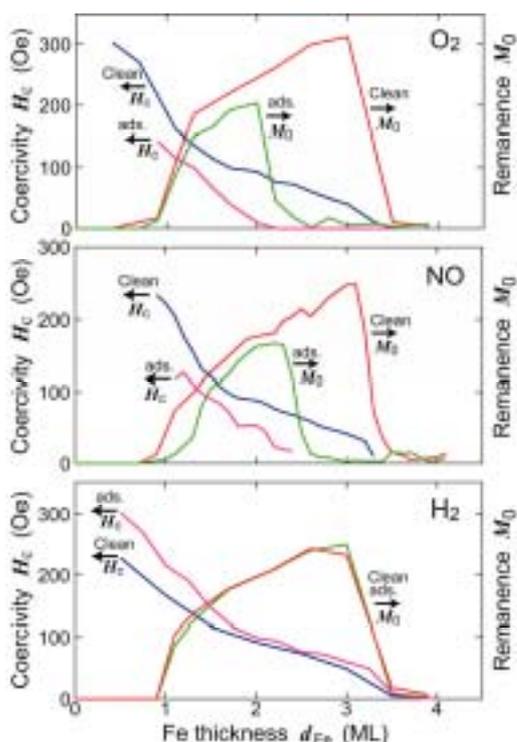


Fig. 1 Remanent magnetization (right axis) and coercive field (left) of 1.2 ML Fe films on Ag(001) before and after gas adsorption, examined by polar MOKE at 100 K.

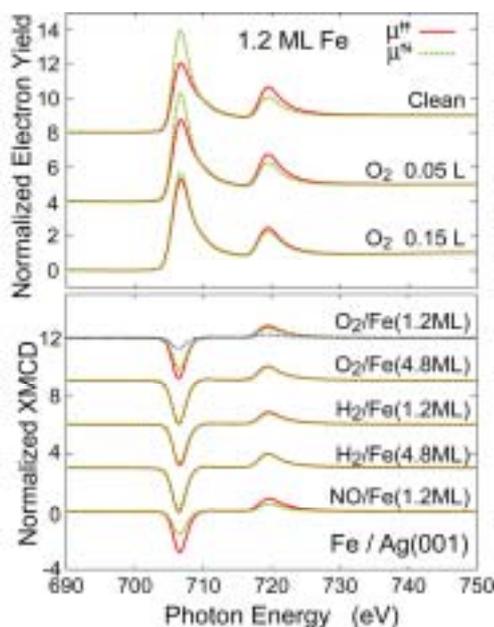


Fig. 2 Fe *L*_{III,II}-edge x-ray absorption and XMCD spectra at 100 K.

X-Ray Magnetic Circular Dichroism of Co Nanowires Grown on Cu(110)-(2×3)N Surface

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Magnetic properties of nanowires are hot subjects in recent years. There have been reported several nanowire systems grown on well-defined single crystal surfaces. Due to their easy aggregation, however, most of them can only be obtained with very small amount of deposited magnetic metal atoms and the thickness of the nanowires along the surface normal direction is usually 1 atomic layer. York *et al.* [1] discovered Co nanowires grown on Cu(110)-(2×3)N that are well separated with each other up to as much as ~2 ML (monolayer) in a nominal coverage. This implies that both the vertical thickness and the lateral width of the nanowire should be 3–4 atomic layers. In the present work, we have tried to detect the magnetization of the Co nanowires by means of the x-ray magnetic circular dichroism (XMCD) technique using a simple electromagnet.

The experiments were performed using an ultrahigh vacuum chamber with a base pressure of $\sim 1 \times 10^{-10}$ Torr. A Cu(110) single crystal was cleaned by repeated cycles of Ar⁺ sputtering and annealing at ~900 K. The (2×3)N surface was prepared by N⁺ sputtering (500 V) and subsequent annealing at ~600 K. A very clear (2×3) LEED (low energy electron diffraction) was observed. Co was deposited on the Cu(110)-(2×3)N surface with a commercial evaporator. The nominal thicknesses prepared were 1.5 and 2.0 ML. The Co nanowire is grown along the [1-10] direction. For comparison, Co on clean Cu(110) was also prepared. On clean Cu(110), rectangular islands are known to be formed with a longer side aligned along the [1-10] direction.

We have at first investigated the magneto-optical Kerr effect (MOKE) of Co on clean and N-terminated Cu(110) surfaces. Although the experiment is still in progress, we have obtained some preliminary information. A blue plot in Fig. 1 is the hysteresis loop of 2 ML Co on clean Cu(110) with the magnetic field parallel to [1-10], a longer side of the rectangular island. On clean Cu(110), the magnetic easy axis always seems to be [1-10] at least up to ~10 ML. On the N-terminated surface, it was found that above 3 ML the easy axis is [001] perpendicular to the nanowire axis, as seen in the red plot in Fig. 1. This may indicate that coalescence of the nanowires occurs at 3 ML. We have not yet obtained good data for 2 ML due to a little too high temperature of 100 K, but suppose that the 2 ML.

The Co L-edge XMCD spectra were taken with the

total electron yield (measurement of drain current from the sample) with the circular polarization factor of ~0.70 under the flipped magnetic field of ± 1500 Oe at ~100 K. The magnetic field was parallel to the x-ray propagation direction, which is perpendicular to the [001] axis. The angle between the nanowire axis and the x-ray helicity is 30° (grazing x-ray incidence). Figure 2 shows the XMCD results. The 2 ML Co on clean Cu(110) exhibits large XMCD signals compared to the reference, in good accordance with the MOKE results in Fig. 1. The Co nanowires of 1.5 and 2 ML Co on N-terminated Cu(110) also show some XMCD signals even at 100 K. The XMCD measurements using a new superconducting magnet and at lower temperature as ~10 K will be conducted in a next beamtime.

[1] S.M York *et al.*, *Phy. Rev. B* **64** (2001) 033411.

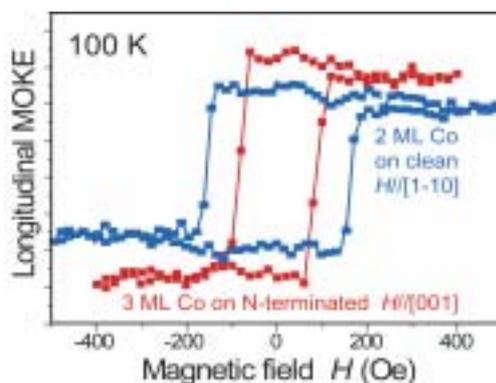


Fig. 1 Longitudinal MOKE of Co on clean and N-terminated Cu(110).

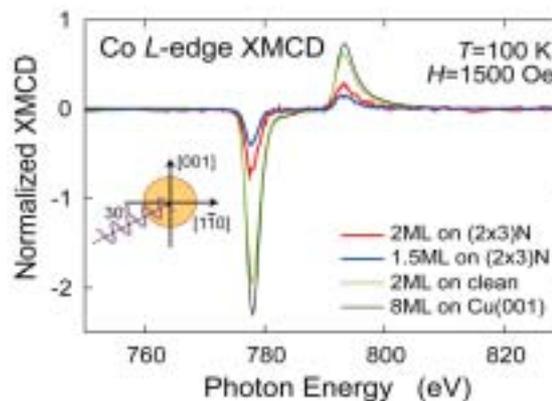


Fig. 2 Co L_{III,II}-edge XMCD.

X-Ray Magnetic Circular Dichroism Study on Fe/Ni(6 ML)/Cu(001)

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Introduction

Magnetism in thin films sometimes much differ from that in bulk because of different structure, the presense of surface and interface. Especially Fe shows variety of magnetism in thin films. For example, Fe on Cu(001) has a fcc-like structure and shows a much reduced magnetic moments, which comes from a partial antiferromagnetic coupling in the films or a formation of spin-density waves. Fe on Ni(7 ML)/Cu(001) also shows a unique magnetism [1], where the total magnetic moment is not proportional to the thickness.

Experiment

The experiment was performed in a ultra-high vacuum chamber at BL4B. The magnetic hysteresis curves were taken by magneto-optical Kerr effect (MOKE), and the x-ray magnetic circular dichroism (XMCD) was taken at BL4B. As shown in Fig. 1, we measured the magnetic moments not only parallel, but also perpendicular to the magnetic field applied using cross-configured magnets or rotating the azimuthal angle of the sample in remanence magnetization.

Result

Figure 2 shows MOKE intensity in an in-plane magnetized Fe/Ni(6 ML)/Cu(001), which is proportional to the magnetization. Note that the contribution of Ni to the MOKE intensity is negligible and that Fe magnetization dominates the MOKE intensity. The MOKE intensity increase around 2-3 ML with the increase of the Fe thickness. However above 3 ML the MOKE intensity decreases with the increase of the Fe thickness. This broken of the magnetization shows that the Fe/Ni/Cu(001) is not magnetized in a single direction, indicating that the Fe has non-collinear coupling such as a antiferromagnetic one. However the antiferromagnetic coupling is ruled out since the magnetic moment does not goes to zero every two layers.

We performed XMCD measurement to evaluate the direction and magnitude of the magnetism. Figure 3(a) shows Fe XMCD spectra on 3 ML Fe/Ni(6 ML)/Cu(001). This shows the Fe magnetization is completely parallel to the magnetic field, in agreement with the MOKE result. Figure 3(b) shows Fe XMCD spectra on 7 ML Fe/Ni(6 ML)/Cu(001). The Fe XMCD is observed in the both directions perpendicular to and parallel to the magnetic field. This shows that the coupling in Fe is 4th-order. Such a coupling comes from a coupling between adjacent interlayers or microscopic domains.

We will adapt a microscopic method such as photoelectron emission microscope to distinguish

between the interlayer coupling and the microscopic domain coupling.

[1] X. Liu *et al.*, Phys. Rev. B **64** (2001) 104408, K. Amemiya *et al.*, Phys. Rev. B **70** (2004) 195405.

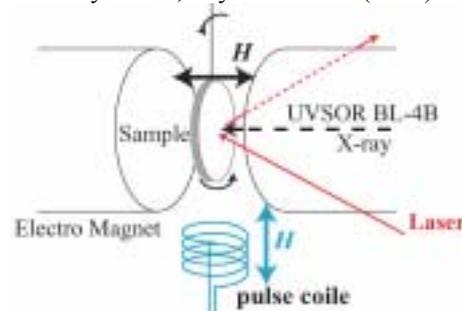


Fig. 1 Experimental setup at BL4B.

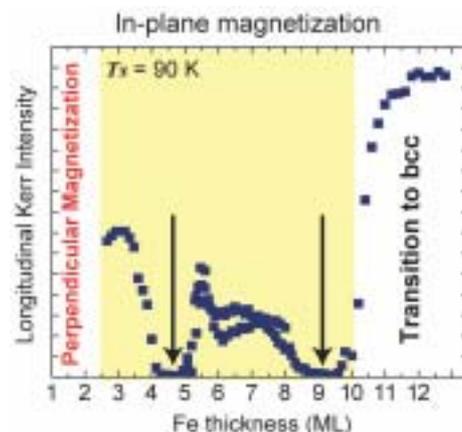


Fig. 2 Longitudinal MOKE intensity on a wedge shaped Fe(1-13 ML)/Ni(6 ML)/Cu(001) as a function of Fe thickness.

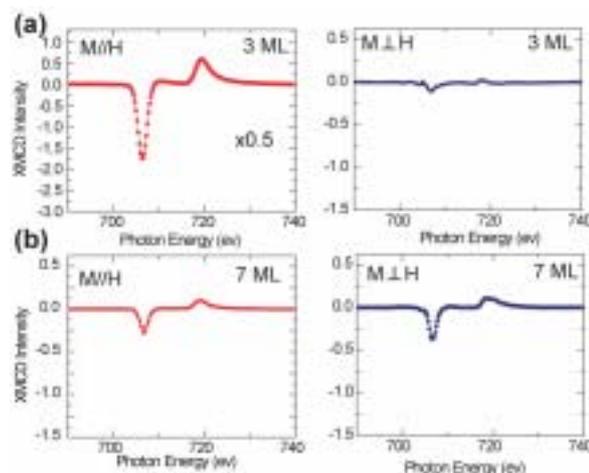


Fig. 3 Fe *L* edge XMCD spectra parallel and perpendicular to the magnetic field. (a) Fe(3 ML)/Ni(6 ML)/Cu(001). (b) Fe(7 ML)/Ni(6 ML)/Cu(001).

Absolute Asymmetric Synthesis of *rac*-Leucine by Circularly Polarized Radiation from UVSOR II-FEL

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The origin of homochirality in biomolecules has been one of the most intriguing issues with severe scientific debates since the early last century. Many hypotheses have been proposed to explain the mechanisms and conditions that led to the terrestrial homochirality. Of these hypotheses, the enantioselective photodecomposition of racemic amino acids by circularly polarized light (CPL) or elliptically polarized light, radiated from a neutron star or a star-forming region, in outer space is believed to be the most plausible mechanisms. Such an asymmetric photoreaction is called “absolute asymmetric synthesis (AAS),” has been demonstrated to occur with a variety of compounds [1]. Recently, it was reported that a variety of amino acids found in Murchison and Lake Murray Meteorites are consistently enantiomerically enriched in the L-form [2]. Furthermore, it was found that the infrared radiation from the star-forming region is highly polarized indeed, reinforcing the idea that the terrestrial homochirality was triggered by the extraterrestrial photochemical event, i.e. AAS [2]

The principle of AAS is that asymmetric photoreactions are brought about through the preferential excitation and subsequent reaction of one enantiomer over the other, via either left- or right-handed CPL (*l*- and *r*-CPL) irradiation. The factor that determines the degree of preferential excitation is called the anisotropy (*g*) factor, and is defined as the relative difference in molar extinction coefficient (ϵ) of each enantiomer towards *l*- and *r*-CPL at a given wavelength: $g = (\epsilon_l - \epsilon_r)/\epsilon = \Delta\epsilon/\epsilon$, where $\epsilon = (\epsilon_l + \epsilon_r)/2$ and $0 \leq g < 2$ [1].

The determination of accurate *g* factor of the target compound is essential in examining the efficiency of AAS. L-Amino acids exhibit a positive circular dichroism (CD) peak around 210 nm and an extremely weak negative CD peak around 250 nm in acidic solutions.[3] The nature of the both CD bands has long been discussed, but the assignment of the CD band around 255 nm has not yet been done. The g at the corresponding wavelength is extreme small, and hence the *g* factor has not been determined for this tiny negative CD peak. Also, the irradiation by CPL at this wavelength has not been examined. However, if the *g* factor of this negative CD peak is appreciable and CPL irradiation leads to photoreaction, the amino acid obtained at this wavelength is opposite in sign from that obtained upon irradiation at shorter wavelengths (e.g. 215 nm). In this aspect, it should be emphasized that the Kuhn-Condon’s zero-sum rule, which claims

that the CD bands of a chiral molecule alternate in sign and sum to zero over the whole spectrum [2], is not applicable to the photoreaction of amino acids in water or ice, as the H₂O absorbs the radiation shorter than ca. 200 nm.

The negative CD peak around 254 nm in acidic solutions [4,5] has been assigned by some researcher to the n, π^* transition of the carboxylic chromophore without considering the contribution of minor conformers. On the other hand, some believe that the negative CD around 254 nm originates from the n, π^* transition of the less stable rotamer(s)[3]. Yet other idea is that the negative CD around 254 nm arises from the coupling of heteroatom’s non-bonding orbital with the chromophoric transition of the carbonyl group [6]. Thus, there still exist the controversial ideas and interpretations about the negative CD bands of L-amino acids at longer wavelengths.

In this research, we will examine the *rac*-Leu samples irradiated at several wavelengths by using the tunable FEL, the full-width at half-maximum (fwhm) of which is extreme narrow and best suitable for the investigation of the present case, where the precise wavelength tuning is essential to exploit the optimum *g* factor for executing the AAS of amino acids. We are now trying to optimize the chemical and physical conditions for irradiation of amino acids by intense FEL.

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Fabrication of Compound Semiconductor Array Using PTFE Templates

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Zinc oxide (ZnO), one of the II-VI compound semiconductors with a wurtzite crystalline structure, is technologically an important material due to its wide range of optical and electrical properties. It has been investigated as functional material for electronic and optoelectronic devices such as transparent conductors, varistors, solar cell windows, and bulk acoustic wave devices. Recently, ZnO has attracted tremendous attention for applications in blue and UV light-emitting diodes, which can be an alternative to those based on III-nitride due to its large exciton binding energy and abundant mineral sources of Zn. Demonstration of ultraviolet lasing from vertically aligned arrays of ZnO rods initiated a great interest in fabrication of ZnO and their applications in various optoelectronic devices. Here, we report a success in achieving periodic arrays of ZnO using polytetrafluoroethylene (PTFE) templates which was patterned by synchrotron radiation (SR) light irradiation.

The irradiation experiments were carried at a beam line, BL8A, in UVSOR facility at Institute for Molecular Science. The critical energy of the SR from the bending magnet field of the 0.75 GeV electron storage ring is 425 eV. The SR light was irradiated perpendicularly to the surface of commercially available PTFE substrates through Ni mesh masks. The proximity distance between the Ni mesh masks and the substrates surface is zero, i.e. the masks were placed on the PTFE substrates directly. ZnO were then grown on the patterned PTFE substrates by metal organic decomposition (MOD) [1]. A commercially available precursor solution for ZnO was used for the MOD deposition. The solution was deposited onto the substrate by spin coating and then thermally annealed in air ambient. Figure 1 and 2 show the scanning electron microscopy (SEM) image and the energy-dispersive X-ray (EDX) spectroscopy, respectively, for the obtained sample. The Zn, F, and O peaks are clearly observed in the EDX spectrum. The cathodoluminescence (CL) spectrum at room temperature under excitation by an electron beam from the sample, is shown in Fig. 3, where exhibits a strong UV emission band at 3.2 eV. Figure 4 shows elemental mapping of Zn for the sample. It is clear that the presence of Zn is uniform within the patterns. Based on these results, we believe that highly ordered ZnO array can be obtained by using PTFE template.

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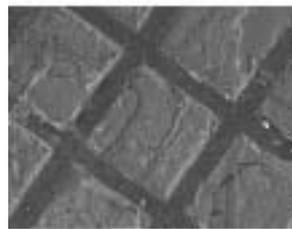


Fig. 1 SEM image of the sample.

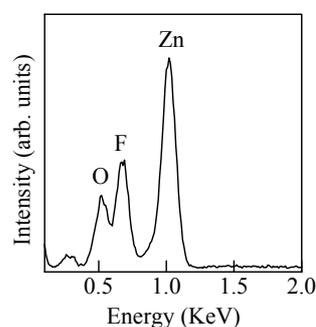


Fig. 2 EDX spectroscopy profile of the sample.

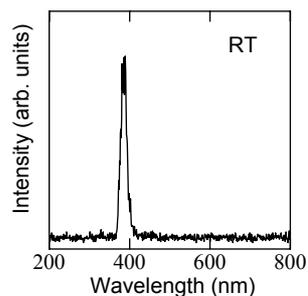


Fig. 3 CL spectrum of the sample.



Fig. 4 Elemental mapping of Zn for the sample