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Magnetization process of Fe/Tb multilayer films by MCD study

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The Fe/Tb multilayer of the composition [Fe 121 nm / Tb 156 nm] × 25 were prepared on Al foil by a dual-type radio frequency sputtering method.

The XMCD measurements were performed on the beam line PF-BL-28B of KEK, Japan. The examples of the XMCD spectra at both Fe *K*-edge and Tb L_3-edge in the magnetic field of 0.62 T at room temperature are shown in Fig.1. The XMCD spectra were normalized with the total thickness of each element, which was estimated from the normal absorption spectra. And those were corrected with the degree of circular polarization of the incidence X-ray. The magnitude of XMCD was estimated with integrating the energy range from 7.107 eV to 7.109 eV in Fe *K*-edge and the energy range from 7.511 eV to 7.521 eV Tb L_3-edge, as shown Fig.1(a), (b). The sign of XMCD of Tb is opposite to Fe. This shows clearly the magnetic moments of Tb in the multilayer are coupled ferri-magnetically with Fe moments in this Fe/Tb sample.

In order to measure the magnetization process of each element separately, we have measured the magnetic field dependence of the XMCD intensity. [1],[2] The sample was at first demagnetized. Then the XMCD intensity was measured at a given magnetic field (reversing up and down). This measurement was repeated by stepwise increasing the magnetic field from 0.02 T to 0.62 T. Thus obtained information corresponded to the initial magnetization of each element in the M-H curve. [2]

The results are shown in Fig.2 as a function of temperature. The magnitude of XMCD in both elements was normalized with that in bulk Fe at 0.62T, 298K and bulk Tb at 0.62T, 200K, respectively. We should note the variety of XMCD with signs. Above T=100 K, both the magnitude of Fe *K*-edge and Tb L_3-edge increase proportional up to H=0.15 T. This suggests both Fe and Tb moments increase with increasing the magnetic field, keeping the ferri-magnetic coupling. Below at T=150K, the magnitude of Fe increases, while that of Tb decreases with increasing the magnetic field.

Below 150 K, the variations of XMCD intensity can be explained by a twisted model; The magnetic moments of Fe and Tb align anti-parallel in the low field. But the magnetic moment of Tb begins to turn to the applied field, keeping the Fe moment constant.

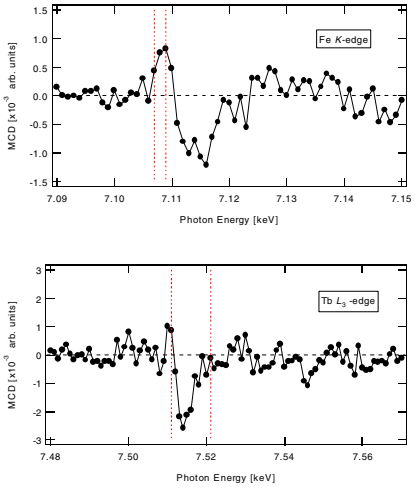

Fig. 1. An example of the XMCD spectra at Fe *K*-edge (a) and Tb L_3-edge (b) in the field of 0.62 T at 298K.

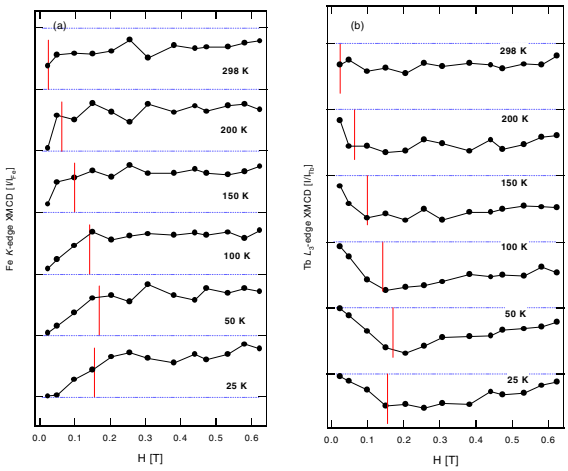

Fig. 2. Field dependence of the Fe *K*-edge (a) and the Tb L_3-edge (b) XMCD integrated intensity at 298K, 200K 150K, 100K, 50K, and 25K, respectively. Longitudinal lines denote the cohesive field in the M-H curve.

References

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