Perpendicular Magnetic Properties of Fe/Tb Multilayered Films

Katsuyoshi TAKANO[1], Miki FURUHATA, Satoru KOBAYASHI[2], Hiroshi SAKURAI, Fumitake ITOH[1]

[1]Department of Electronic Engineering, Gunma Univ., 1-5-1 Tenjin-cho, Kiryu-shi, Gunma, 376-8515, Japan
[2]Satellite Venture Business Laboratory, Gunma Univ., 1-5-1 Tenjin-cho, Kiryu-shi, Gunma, 376-8515, Japan

The Fe/Tb multilayer samples of the composition [Fe 5.9nm/Tb *x* nm (*x* =0.8, 1.3, 1.6, 2.0)] ×125 were prepared on Al foil by MBE at the SVBL, Gunma Univ. . The XMCD measurements were performed on the beam line PF-BL-28B of KEK, Japan. The magnetic absorption profiles were measured at the Fe *K*-edge and Tb $L_{2,3}$-edges under the magnetic fields of 0.6 T applied parallel to the sample plane, which was enough to saturate the samples. The XMCD spectra were normalized with the total thickness of each element, and corrected with the degree of circular polarization of the incidence X-ray.

The area intensity of first peak of the Fe *K*-edge XMCD spectra in multilayers (Fig 1(a)) is almost similar to evaporated bulk Fe. Therefore the magnetic moments of the Fe do not change in these samples.

Tb atoms in the multilayer are magnetized even at the room temperature, because the XMCD effect were observed well above the Curie temperature of Tb metal (220K) in Fig 1(b). The intensity of the Tb $L_{2,3}$-edges XMCD spectra in multilayers is almost similar to bulk Tb, while signs of the Tb $L_{2,3}$-edges in the multilayers are opposite to bulk Tb. Therefore the magnetic moments of Tb in multilayer are coupled ferri-magnetically with Fe moments in the Fe/Tb system. Intensities of the Tb $L_{2,3}$-edges decrease with decreasing the Tb thickness. These observations are consistent with the reported decrease of the spin polarization of Tb in amorphous and multilayers [1][2]. This may be ascribed to the change of electronic structure.

The ratio of the orbital to the spin moment, M_{orb}/M_{spin}, on Tb 5*d* using the magneto-optic sum rule [3][4], is shown in Fig 2. M_{orb}/M_{spin} decreases with decreasing the Tb thickness, and becomes almost zero at the Tb thickness of 0.8 nm. It has been reported experimentally that the M_{orb}/M_{spin} decreases in Fe-Tb amorphous alloys with the decreases of Tb proportion [1]. But the disappearance of M_{orb}/M_{spin} has not been reported so far. We speculate that the disappearance of M_{orb}/M_{spin} is caused by the change in electron state at Fe/Tb interface due to strong hybridization between Fe 3*d* and Tb 5*d*. This observation implies that the Tb moment is not responsible for the perpendicular anisotropy of Fe-Tb systems. More experiments and theoretical calculations with the spin polarization in this system are needed.

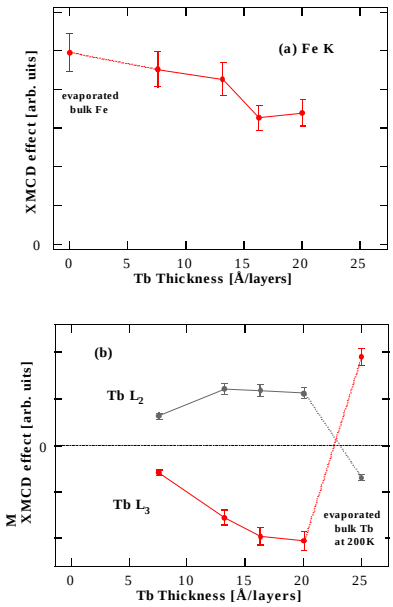

Fig 1. The intensity of XMCD effect in [Fe 5.9nm/Tb x nm (x=0.8, 1.3, 1.6, 2.0)]$_{125}$; (a) at the Fe *K*-edge and (b) Tb $L_{2,3}$-edges.

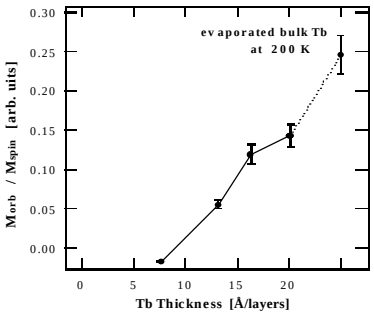

Fig 2. The ratio of M_{orb}/M_{spin} on Tb 5*d* in [Fe 5.9nm/Tb x nm (x=0.8, 1.3, 1.6, 2.0)]$_{125}$ and evaporated bulk Tb.

References

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*ktakano@el.gunma-u.ac.jp