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Coercivity and local structure of Fe/Cr multilayer films

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Introduction

In 1989, a reluctance effect of metal multi-layer film (Fe/Cr/Fe structure) was first discovered [1]. When the quite thin films of Fe and Cr were deposited alternatively on the top of the substrate, the reluctance changes an external magnetizing field. It becomes indispensable now to bring about a new field in nanotechnology called the spin electronics (spintronics). To reveal the mechanism of the reluctance change, the local structure is important to study in the each film. EXAFS is unique tool to study of local structure for such a multi-layer structure, because of its element selectivity. In this report, we performed the EXAFS analyses for Fe/Cr multi-layer film by each K-edge of Fe and Cr.

Experimental

The Fe/Cr multi-layer films were prepared with various kinds of film thicknesses by RF high frequency magnetron sputtering method. The sample thicknesses were controlled by the deposition time. The Fe and Cr films of 10nm, 25nm, 50nm, 100nm, were piled up on the glass and its total film thickness was set to 300nm. The sample of 40nm Fe/Cr may be presumed by alloy. All samples measured at present study are listed in Table. The magnetic characterization (mainly coercivity) of the Fe/Cr multi-layer films were performed by VSM. The measurements of the X-ray absorption spectra were performed at BL9C by use of fluorescence mode with Lytle detector.

Results and discussion

Figure 1 shows Fourier transforms of EXAFS of the Fe *K*-edge. The main peak in the vicinity of 2.4 Å shows the contribution from the nearest neighboring atom (Fe:2.48 Å). Because Fe and Cr have BCC structure, the second nearest neighboring atom (Fe: 2.866Å) is included in the first peak. It can be seen that the peak intensity changes as a film thickness. Furthermore, we performed a curve fitting analyses and obtained structure parameters. Figure 2 shows the plots of the EXAFS Debye-Waller factor for the first nearest neighbor atom as a function of the coercivity of the sample. It can be seen the correlations between the Debye-Waller factor and the coercivity. Thus, the sample which had a small Debye-Waller factor shows the large coercivity. Because the Debye-Waller factor is an index to express the disorder of local structure, this result indicates that the multi-layer film sample having a stable local structure shows the large coercivity. Furthermore, it is suggested that the thinner multi-layer films shows the smaller Debye-Waller factor, or the more stable local structure.

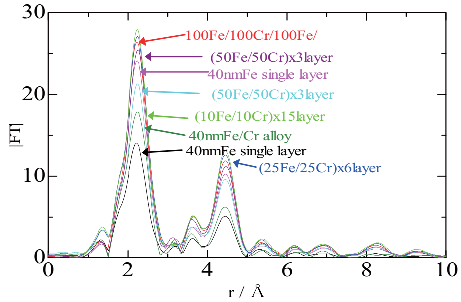

Fig. 1 Fourier transforms of Fe K-edge EXAFS for various thicknesses of Fe/Cr multi-layer films and alloy.

Table Debye-Waller factors for Fe-Fe atomic pairs and coercivity for the present Fe/Cr multi-layer films.

Sample	σ / Å	Hc/Oe
A-40nmFe single layer	0.080	21.8
B-40nmFe single layer	0.097	9.0
40nmFe/Cr alloy	0.095	10.0
100Fe/100Cr/100Fe	0.076	12.0
A-(50Fe/50Cr)x3layers	0.080	16.4
B-(50Fe/50Cr)x3layers	0.083	7.0
(25Fe/25Cr)x6layers	0.075	16.5
(10Fe/10Cr)x15layers	0.073	20.0

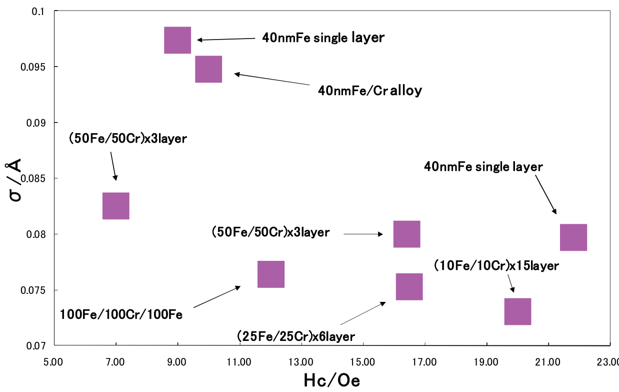

Fig. 2 Relations of Debye-Waller factor for first nearest Fe-Fe and the coercivity for the various Fe/Cr multi-layers films and alloy.

References

[1] M.N.Baibich *et* al.,Phys.Rev.Lett.**61**,2472 (1988).