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Soft-X-ray fluorescence under standing-wave excitation from interdiffused layers in Fe/Si multilayers

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Introduction

Fe/Si multilayers are widely studied from the aspect of interlayer magnetic exchange coupling. We have assigned the mediating layer for the interlayer coupling to be an amorphous $FeSi_2$ layer of 0.7 nm thick resulted from interdiffusion using soft X-ray fluorescence (SXF) spectroscopy [1]. Besides, using a total-reflection SXF spectroscopy a SiO_2 layer was confirmed to locate in the topmost Fe_3Si layer [2]. Fluorescence intensity from the interdiffused layers is absolutely low. The standing-wave technique has been established in the X-ray region. Soft-X-ray standing waves generated in the multilayers under the Bragg reflection could enhance the fluorescence intensity from the interdiffused layers.

Experimental

An Fe(2.6nm)/Si(2.6nm) multilayer was prepared using a dc magnetron sputter system. It was grown to 22 bilayers with a topmost Fe layer. This sample has been studied using usual SXF spectroscopy [1]. The SXF experiment was carried out at BL-16B using an SXF spectrometer of a flat-field focusing type based on a 1200-grooves/mm grating (Hitachi, 001-0437). The slit width of the spectrometer was 0.1 mm, and the resolution was about 0.4 eV at 100 eV. The angle of incidence of the primary photons for the sample was adjusted with a precision of 0.1° using a sample manipulator (VG, RD1) with its rotation axis oriented vertically.

Results

Figure 1 shows the Si $L_{2,3}$ fluorescence spectra from the Fe/Si multilayer at 118.4 eV for grazing angles of incidence of 60° and 69° with a blue thick and a red thin line, respectively. A slight difference is found between the two spectra in the shoulder region. Figure 2 shows the difference obtained by subtracting the spectrum of 60° from that of 69°, together with a result of a curve fitting analysis using the Si $L_{2,3}$ fluorescence spectra of a-Si and several silicides [1]. Relative changes in the fluorescence intensity for the component layers are summarized in Table I. It is quite reasonable from a simulation study that the intensity of the Si layer decreases relatively. However, that of the Fe_3Si layer also decreases unexpectedly. This is explained from the result that the Fe_3Si layer decreased in the intensity, whereas the SiO_2 layer increased complementarily. This tendency is fairly consistent with the result obtained by the total-reflection SXF study [2]. This means that the effect of the standing waves is remarkable in the vicinity of the multilayer surface.

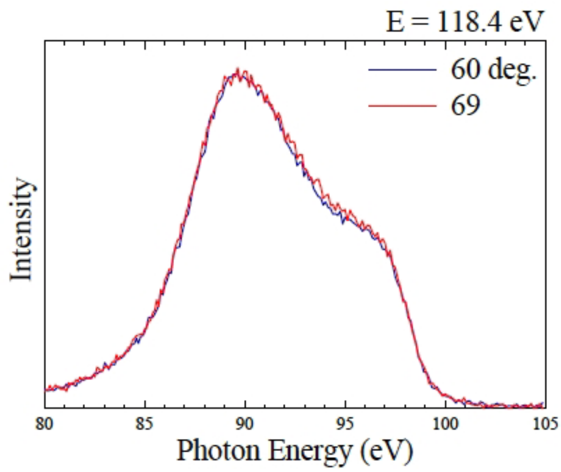

Fig. 1. Si $L_{2,3}$ SXF spectra from an Fe(2.6nm)/Si(2.6nm) multilayer for grazing angles of incidence of 60° and 69°.

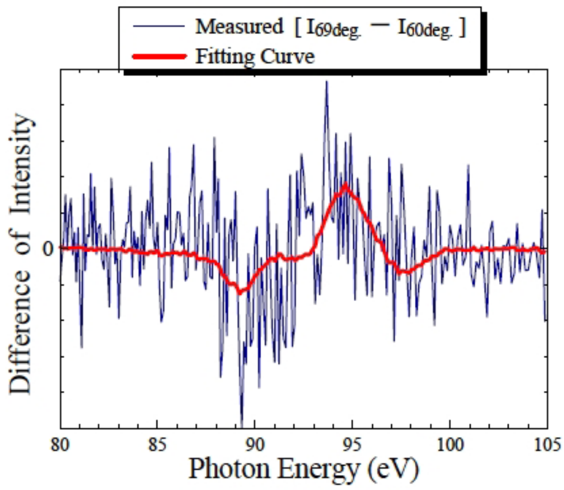

Fig. 2. Difference spectrum between the two spectra shown in Fig. 1 and a result of a curve-fitting analysis.

Table I. Relative changes in the SXF intensity for the component layers.

Components	Fe_3Si	FeSi	$FeSi_2$	a-Si	SiO_2
Change (%)	- 3.4	+ 2.1	+ 0.6	- 1.1	+ 1.8

References

[1] T. Imazono *et al*., Jpn. J. Appl. Phys. **43**, 4327 (2004).
[2] T. Imazono *et al*., Jpn. J. Appl. Phys. **43**, 4334 (2004).

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