Interfacial diffusion in Fe/Cr multilayers studied by synchrotron x-ray techniques

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The discovery of giant magnetoresistance (GMR) in Fe/Cr multilayers has produced much interesting experimental and theoretical work.[1] Especially, the interface study of Fe/Cr multilayers is very important, because the spin dependent scattering mostly occurs at the interfaces. In this work, we have studied the interfacial diffusion of Fe/Cr multilayers using synchrotron x-ray techniques, such as x-ray reflectivity, extended x-ray absorption fine structures (EXAFS), high-resolution x-ray scattering, and anomalous x-ray scattering (AXS). $[Fe(10\,Å)/Cr(4\,Å)]_{24}$ (FCr-4) and $[Fe(10\,Å)/Cr(40\,Å)]_{29}$ (FCr-40) multilayers with different Cr thickness were prepared on MgO(001) substrates using ultrahigh-vacuum deposition system with e-gun heating.[2] In the FCr-40 multilayer, the overall intensity of the x-ray reflection dramatically decreased compared to that of the FCr-4 multilayer with submonatomic Cr layers. The full width at half maximum (FWHM) of the rocking curve at satellite peaks of FCr-40 multilayer was large as 1.20°, compared to that of FCr-4 multialyer, 0.99°. These results indicate that Fe/Cr interfacial roughness increases with the Cr thickness. The Fourier transform (FT) of EXAFS data at Cr K-edge (5989 eV) showed that the nearest neighbor structure around Cr atoms of the FCr-4 and FCr-40 multilayers were similar to that of standard Cr-foil. The nearest neighbor structure around Fe atoms of FCr-40 multilayer, however, was different from that of FCr-4 multilayer and standard Fe-foil. We believe that the Fe atoms dominantly diffuse into the Cr layers at the Fe/Cr interface. We also carried out AXS at the Bragg reflection of Cr(002), $q=4.358\,Å^{-1}$, to confirm the interfacial diffusion of Fe atoms into Cr layers. A cusp at the Bragg reflection of Cr(002) around the Fe K-edge (7112 eV) was clearly observed, indicating the existence of the diffused Fe atoms in the Cr layers. Our study revealed that the rough interface of the Fe/Cr multilayers was caused by the dominantly interfacial diffusion of Fe atoms into the Cr layers.

References

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