Grazing-incidence X-ray scattering study on Co/Ru superlattices

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Introduction

Recent advances in materials science reveal that artificial hetero structures in nano-meter scale can provide unique and exotic properties, especially for magnetic materials. In this report, the structure of Co/Ru superlattices carefully prepared by monolayer-scale deposition [1] has been investigated by grazing incidence X-ray scattering.

Experimental

The sample measured is $[Co(4ML)/Ru(4ML)]_{26}$ (CU4A), deposited on a sapphire $(11\bar{2}0)$ substrate with a Ru(0001) buffer (~200Å). Note that each layer thickness is only 8~9Å. For the preparation, a special evaporation technique developed by Takanashi and his coworkers has been employed. The experiment was carried out at BL-14A with 16keV monochromatic X-rays. Details of the grazing incidence X-ray reflectometer can be found elsewhere [2].

Results and Discussion

Fig.1 shows the specular reflectivity for the CU4A superlattice. Although Kiessig fringes (corresponding to the total thickness of 16 layer pairs and also the buffer layer thickness) are clearly seen in the low angle region, one might notice that the 1st Bragg peak (at 22.57mrad) is very weak and even assignment is not easy. Compared with a calculation assuming an ideal layered structure and interfaces, the experimental reflectivity is smaller than 1/20. Although such attenuation would be mainly due to interface roughness as well as inter-diffusion (alloying), it was not possible to obtain a good fit by theoretical calculation based on the Parrtatt's model [3]. In the present case, it is probably necessary to assume that interface roughness is larger than layer thickness. The d value obtained is 3.2% larger than the ideal lattice constant calculated for the bulk crystal.

Fig.2 shows the results of the detector scan. When the grazing angle is fixed at the Bragg angle, a single specular peak was seen at 45.14mrad. However, when the grazing angle slightly shifts from the Bragg condition (θi=21.47mrad), two peaks were found at 42.94 (specular) and 45.14mrad (Bragg). The diffuse/specular intensity ratio at the Bragg peak is around 1.6%. The existence of rather strong Bragg diffuse scattering can be explained by the conformal roughness [3]. That is, interfaces would be strongly correlated each other. In summary, weak specular Bragg reflection and rather strong diffuse Bragg scattering are observed. This indicates that Co/Ru superlattices definitely maintain a periodic layered structure in spite of their extremely thin layer pairs and somewhat large interface roughness. The author would like to thank Dr. H. Eba and Dr. S. Kuwajima for their assistance during the experiments.

References

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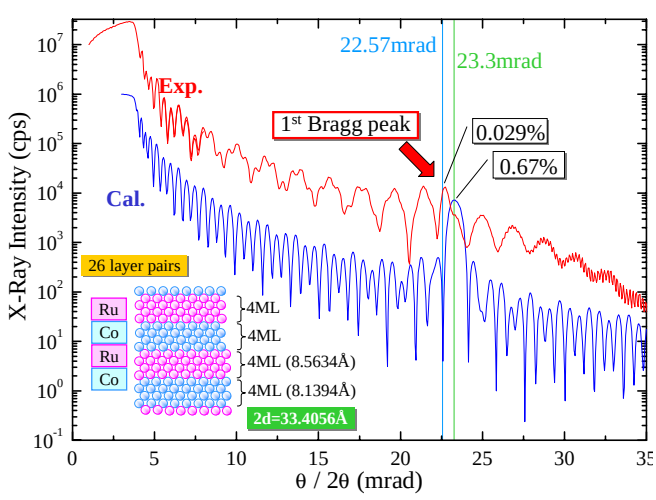

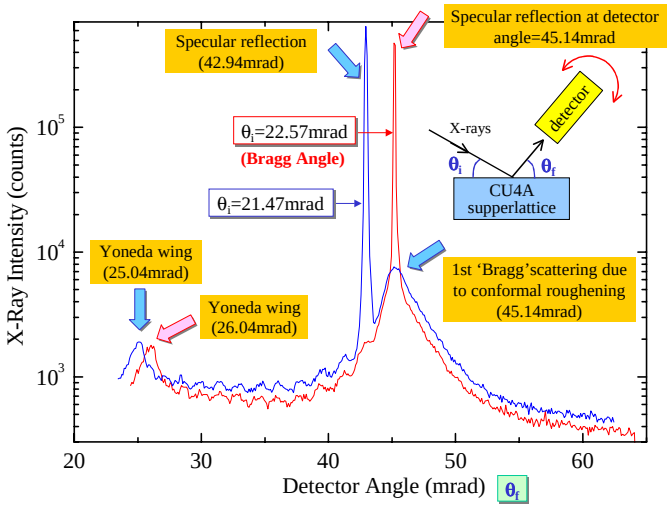

Fig.1 (left) Experimental and calculated X-ray specular reflection.
Fig.2 (right) Diffuse scattering measured by detector-scan at Bragg (θi=22.57 mrad) and off-Bragg (θi=21.47 mrad) incidence angles.