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Spin arrangement of the Mn / Fe(001) system investigated by spin polarized photoelectron diffraction

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Introduction

In principle, using the spin polarized photoelectron diffraction (SPPD) method, one can determine the short-range magnetic order of the surface atoms, in addition to the atom specific or chemical-state specific surface structure. In the present paper, we demonstrated this SPPD method applied to the Mn(~1 ML) overlayer on Fe (001) system and investigated the spin arrangement of Mn and Fe atoms separately. The measured Mn overlayer in submonolayer regime on Fe(001) is one of the most controversial system and widely investigated both experimentally and theoretically. In spite of the numerous studies, there is no consensus about the magnetic coupling between Mn and Fe interface or between neighboring Mn atoms, and many models of spin arrangement are proposed so far[1,2] as summarized in Fig.1.

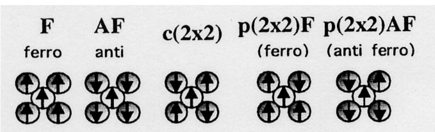

Fig.1 So far proposed models of spin arrangement of Mn monolayer. Shaded and open circles represent the Mn and Fe atoms. The direction of arrows in the circle indicates the direction of magnetic moment.

Experimental

All experiments were performed at the beamline BL-19A. Fe(001) thin film (~ 12ML) was grown at room temperature by electron-beam evaporation on the Ag(001) single crystal substrate, cleaned by a cycle of Ar^+ ion sputtering at 500 eV and post annealing at 650 °C. 1ML or less Mn was deposited on to the Fe(001) thin film and the thickness of the Fe epitaxial film and the coverage of the Mn were estimated by the intensity ratio of Auger spectra. The sample was remnantly magnetized *in situ* along [010] direction by magnetization coils. Linearly polarized light at hν =127 eV was injected along surface normal direction([001]) and the emitted photoelectrons are detected along the [010] direction by the polar angle scan with the angle-resolved electron analyzer. Spin polarization of the photoelectrons is detected by small Mott-type spin detector which is equipped at the end of the electron analyzer[3]. The total energy and angular resolutions are 0.4 eV and ±2°.

Results and Discussion

We plotted observed angular distribution of the spin polarization of Mn 3p and Fe 3p core in Fig.2.

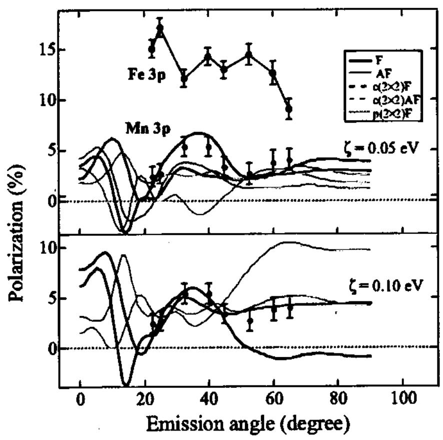

Fig.2 SPPD curve of Fe 3p (open circles) and Mn 3p (filled circles) core levels. Mn 3p results are compared with the calculated SPPD curves for the models indicated in Fig.1.

Filled and open circles with error bar are the polarization of Mn 3p (E_B=47.9 eV) and Fe 3p (E_B=52.7 eV) core levels. In the figure, we also plotted the calculated SPPD curves[4] for the aforementioned models. In the calculation, as well as the flat Mn overlayer, we take into account of the surface reconstruction having c(2×2) symmetry caused by the Mn atom buckling which is suggested by Wu and Freemen[2]. The c(2×2)F and c(2×2)AF in the figure mean that the magnetic moment of the upper Mn is parallel and anti-parallel to that of the substrate Fe in the case of c(2×2) spin configuration with the c(2×2) surface reconstruction. As seen in the figure, assuming the value of ς(= 3Δ_{ex}:spin exchange splitting), as 0.05 eV, ferromagnetic Mn arrangement coupled ferromagnetically with Fe substrate (thick solid curve; labeled F) reproduces our experimental results quite well. In the case of ς=0.10 eV (lower part of Fig.2), the c(2×2)F arrangement (thick dashed curve) well reproduces the experimental results. However, other spin arrangements, cannot reproduce the experimental SPPD curve.

References

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