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Spin resolved photoemission excited by VUV-circularly polarized light of Ni(110)

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We have performed spin- and angle- resolved photoemission spectroscopy for the Ni 3d valence band using vuv-circularly polarized synchrotron radiation (hν=60-80eV) at BL-28A. Photoelectrons were collected by a hemispherical electron energy analyzer and an electron spin was analyzed by our recently developed small Mott scattering detector operated at 25kV whose efficiency is 1.9×10^{-4}. The angle of incidence of the undulator light was 75° from the surface normal. The photoelectrons emitted normal to the sample surface were collected.

The definitions of the experimental spectra are tabulated in Table I. Magnetic circular dichroism (MCD) in the spin-integrated spectra can be obtained by the formula, $I_{++} + I_{+-} - I_{-+} - I_{--}$. Furthermore, $I_{++} - I_{-+}$ ($I_{+-} - I_{--}$) produces the MCD asymmetry in majority (minority) spin channel. As shown in Fig.1 (a), both of the spin integrated spectra taken at hν=80eV show the peaks around E_B=1eV It is found that the binding energy (E_B) of the spectrum for the plus helicity ($I_{++} + I_{+-}$) is 0.1eV lower than that for the minus helicity ($I_{-+} + I_{--}$), which results in the dispersive asymmetry in the difference spectrum between the spin-integrated spectra [Fig.1 (b)]. One can further find that the asymmetry in the minority spin channel is remarkable compared to that in the majority spin channel as also confirmed in the MCD spectra [Fig.1 (b)]. This result indicates that the MCD appeared in the spin-integrated spectrum is mainly derived by the minority spin bands. On the other hand, the observed asymmetries are not clearly recognized in the spectra excited at hν=60eV compared to those for the spectra at hν=80eV (*not shown here*). [1] MCD asymmetry in the valence band photoemission spectra of the 3d ferromagnets has been interpreted to be derived mainly from the spin-orbit (s-o) induced initial state hybridization between the electronic band states with different spatial symmetries, which has been probed by the recent angle-resolved photoemission experiments combining with the theoretical analysis based on the relativistic band structure of 3d ferromagnets. Such an hybridization is expected to be stronger for the different spatial symmetry bands with smaller energy separation. Indeed, the energy separation between Σ_1 and Σ_3 symmetry bands is much smaller (1eV) near Γ point (hν=80eV) than that at the middle point of ΓK (hν=60eV) because the Σ_1 state shows the upward dispersion whereas the Σ_3 state shows downward dispersion along Γ-K direction. [2] Thus the s-o induced hybridization is expected to be remarkable for these bands especially near Γ point. Furthermore, our spin-dependent MCD results possibly show that the s-o induced hybridization is larger for the minority spin states than that for the majority ones.

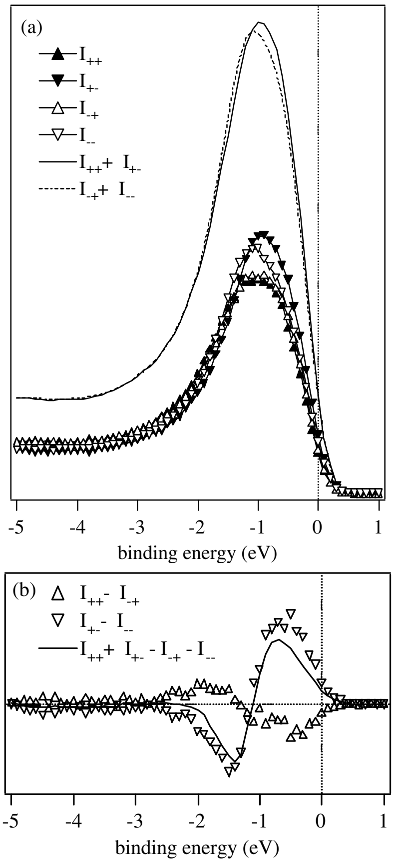

Fig.1

Table I. Definition of the experimental spectra.

I_{ab}	a: helicity of incident light	b: spin direction
I_{++}	positive (Δm=+1)	majority spin
I_{+-}	positive (Δm=+1)	minority spin
I_{-+}	negative (Δm=-1)	majority spin
I_{--}	negative (Δm=-1)	minority spin

References

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