IMS

Magnetic Circular Dichroism in Valence Band using Laser Excitation

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Recently the magnetic circular dichroism has been a widely used method since it can detect the magnetic properties of thin films without spin detector, namely the measurement is simple and efficient. However valence band magnetic circular dichorism is generally known to be tiny due to the weak spin orbit coupling in valence band. Together with angle and energy resolved photoemission, it has been revealed that the MCD asymmetry is large enough to be measured (~10 %).[1] Enhanced MCD also can be obtained in threshold photoemission with total electron yield method,[2,3] but away from the threshold the MCD asymmetry is drastically reduced. Since the valence band electron excitation is achieved by pulse lasers, it is expected that MCD in valence band would be investigated by multiphoton process.[4] Although in principal the multiphoton MCD process is possible, it is completely unclear how much asymmetry is achieved.

We report an observation of two photon photoemission (2PPE) magnetic circular dichroism (MCD) on Ni(15 ML)/Cu(001) near the Fermi level using short pulse laser.[1, 2] Figures 1(a) and (b) show ARPES spectra and the MCD asymmetry for 2PPE. The spectra are taken along the surface normal using circularly polarized light. Ni 3d peak are observed near the Fermi level, and the 3d peak shows slight shift by inverting the direction of the magnetization, which is the manifestation of MCD. The derived MCD spectra show ~20 % asymmetry

The reduction of Ni MCD asymmetry by the overlayer metal capping is examined. It is believed that the electron escape depth for low kinetic energy is large, ~10 nm. However the estimation of the escape depth usually neglects the diffraction effect of electrons by overlayers, which is significantly important for the angle resolved photoemission experiments. Fig.1 (c) plots the variation of the MCD asymmetry by increasing the Cu overlayer onto the Ni film and it is found that for the electron kinetic energy of ~ 1 eV the attenuation depth is only ~2 ML (0.32 nm) for Cu deposition, which is much smaller than the escape depth by universal curves (~10 nm). This reduced electron escape depth is explained by electron diffraction effects when the photoelectrons pass through the capping layer.

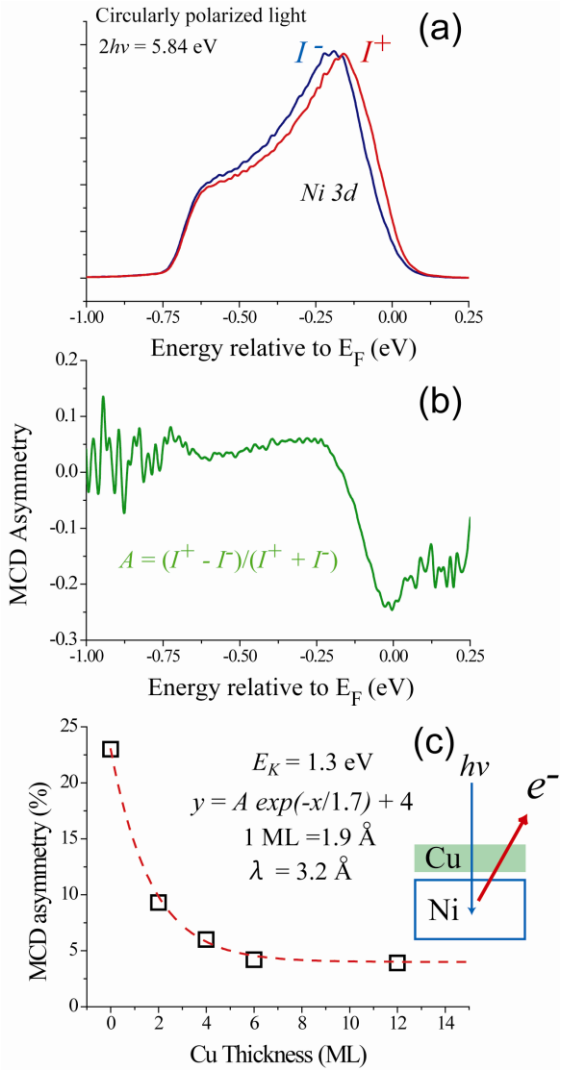

Fig. 1 (a) Two photon ARPES spectra for Ni(15 ML)/Cu(001) sample. The sample magnetization is inverted by pulse coil and the helicity of the circularly polarization is fixed. (b) MCD asymmetry derived from the spectra in (a). (c) The variation of the MCD asymmetry by increasing the thickness of Cu overlayer.

[1] T. Nakagawa, and T. Yokoyama, *Phys. Rev. Lett.* **96**, 237402(2006).
[2] T. Nakagawa *et al.*, *Phys. Rev.* B. **79**, 172404 (2009).