Atomic-layer resolved electronic structure analysis by 2D-XAFS/XMCD

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The atomic and electronic structures of outermost surface have been extensively investigated by PEEM and LEEM techniques as well as various scanning probe microscopies, whereas much difficulty lies in the case of subsurface atoms and buried interface. Here we report a direct method for such purpose. Photoelectron and Auger electron diffractions from a localized core level provide information on the surrounding atomic configuration which is recorded as the forward focusing peaks (FFPs) at local interatomic directions and the diffraction patterns around them [1, 2]. Taking advantage of the forward focusing peak (FFP) as an excellent element- and site-selective probe, we have developed a new method of two-dimensional XAFS and XMCD for the investigation of the atomic, electronic and magnetic structures of surface and thin film.

The experiments were performed at the circularly polarized soft x-ray beamline BL25SU of SPring-8, Japan [3], using our Display-type analyzer, where two-dimensional angular distribution of specific kinetic energy photoelectron is measured at once [1, 2, 4, 5].

A wedged Ni thin film with maximum thickness of 9 monolayer (ML) was deposited on the clean Cu(001) surface at room temperature. Ni-L edge XAFS spectra at various Ni film thicknesses were acquired by measuring Ni LMM Auger patterns (kinetic energy: 870 eV) excited with normal incident soft x-ray. The Auger electrons emitted from the Ni atoms in the 2nd and 3rd layers contribute to the FFP intensities at [101] and [001] directions, respectively, whereas the intensity at the extremely low emission angle is mainly due to the Auger electron emission from the outermost surface atoms. In the case of Ni 5-9 ML film, the Ni L3 XAFS peak of the grazing emission region shifts to higher energy by 0.1 eV compared to those of FFPs at [101] and [001]. The layer-by-layer electronic structure for each film thickness is analyzed based on these thickness dependences of two-dimensional XAFS data.

Furthermore, the Ni wedged film was magnetized along surface normal direction. Series of Ni LMM Auger patterns excited by positive and negative helicity light were measured for various film thicknesses. XMCD spectrum for each layer was extracted and investigated.

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