Excitation energy dependence of photoelectron-phonon interaction on Cu surface excited by laser light

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In recent times, laser photoemission (LPE) spectroscopy has emerged as a powerful tool for probing surface electron dynamics. For example, two photon photoemission spectroscopy is well known as an ideal technique for monitoring the decay process of image states at the surface. We propose a novel application of this technique to measure phonon properties at a solid surface. (Here, "phonon" also refers to adsorbate vibrations.) In a previous study[1], we reported that an energy loss process due to vibrational excitation during LPE. To establish LPE spectroscopy as a novel vibrational spectroscopic tool, it it necessary to understand the mechanism of the inelastic interaction between the photoelectron and the phonon.

The present study investigates the excitation energy dependence of the cross section for this inelastic interaction on a Cu(110) surface. In the LPE spectra of the clean Cu(110) surface ($\Phi :\sim 4.52$ eV), the inelastic component arising from the generated phonons appeared as the step at 15 meV [2]. The step height, which corresponds to the cross-section, rapidly decreased as the photon energy ($h\nu$) increased, for $4.5 < h\nu < 5.0$ eV. For $5.0 < h\nu < 6.0$ eV, the step height was low and the $h\nu$ dependence was weak. We also measured the $h\nu$ dependence of the O/Cu(110) surface, which has a higher work function ($\Phi :\sim 5.0$ eV). A step appeared at 15 meV and the $h\nu$ dependence was weak in the energy range of $5.0 < h\nu < 6.0$ eV. These results suggest that the cross-section for this inelastic interaction was mainly determined not by the kinetic energy of photoelectron but the photon energy. Finally, we discuss a feasible scenario of the inelastic photoemission process.

This work was supported in part by the PRESTO program of the Japan Science and Technology Agency (JST).

[1] R. Arafune *et al.*, PRL **95**, 207601 (2005).

[2] R. Arafune *et al.*, PRB **80**, 073407 (2009).