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Experimental Determination of Electron Effective Attenuation Length in Au Thin Films

Motoyasu IMAMURA*,Eiichi KIBAYASHI and Nobuyuki MATSUBAYASHI
NMIJ, AIST, Tsukuba, Ibaraki 305-8565, Japan

Introduction

Values of effective attenuation lengths (EALs) of electrons are needed in quantitative investigations by Auger electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS). The inelastic mean free paths (IMFPs) are often used for this purpose, with IMFPs obtained from optical data or a predictive formula. However, recent calculations have shown that elastic electron scattering is not negligible .

In this study, we measured EALs of photoelectrons of various energies in gold thin films using synchrotron radiation (SR) as an excitation source and compare these EALs with calculated EALs.

Experimental

Au thin films were fabricated using electron beam evaporation system. The electron beam gun with power of 2 kW was equipped to a high vacuum chamber. A load-lock system was used to load and unload the samples quickly and easily without breaking the vacuum of the main chamber. The base pressure of the chamber was $1x10^{-7}$ Pa. The platinum plate with a thickness of 0.1 mm was hold on the sample holder. The thickness of the films was determined by the deposition monitor. The pressure during evaporation was $1x10^{-5}$ Pa. After evaporation, the sample was put into a vessel attached directly to the load-lock chamber, by which the sample was transferred to the XPS chamber.

SR-XPS measurements were performed at beamline 13C of the Photon Factory. The relative energy resolution was about 3000 for x-ray energy below 500 eV, and was about 1500 for x-ray energy over 500 eV. Photoelectron spectra were measured by a PHI 1600C hemispherical analyzer. The analysis area was circular with a diameter of 0.8 mm, and the analyzer acceptance angle was ±7˚.

Results and Discussion

Figure 1 shows the XPS spectra of Au thin film on the Pt substrate with a thickness of 1 nm excited by various energy. The Au 4f peaks from the thin films and the Pt 4f peaks from the substrate appears, whose intensities reflect the EALs of Au and the photoionization cross sections of Au and Pt. The peak intensities were analyzed by curve fitting. To compensate the influence of the cross sections, the XPS spectra of the Au plate and the Pt plate were also measured and employed for the data analysis.

Figure 2 shows the EALs as a function of the kinetic energy of the electron determined from the intensities of the XPS spectra of thin films with the thickness of 1nm and 2nm. The EALs calculated by the NIST database are also displayed. The EALs determined from the spectra agree with those calculated from the database in the region above 200 eV. However, in the region below 200 eV, EALs determined form the spectra show higher values than the calculated EALs. The difference might be caused by the elestic scattering of the electrons in the thin films, which is not considered in the calculation models of the database.

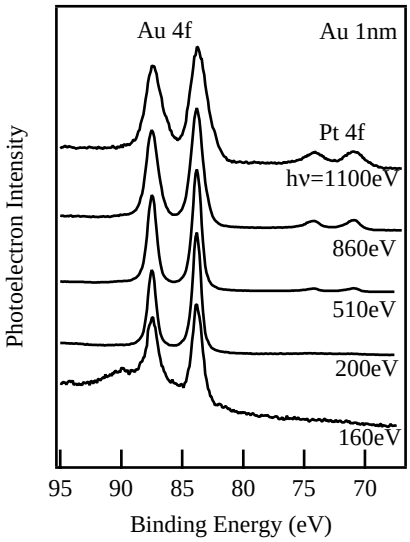

Fig.1 XPS spectra of Au/Pt thin film with a thickness of 1nm.

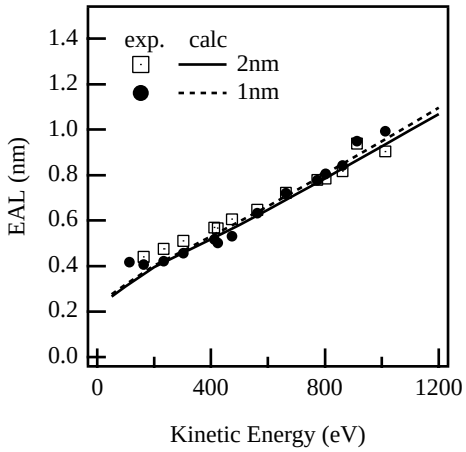

Fig.2 EALs determined from the XPS spectra and calculated by the NIST database.

* motoyasu.imamura@aist.go.jp