

Construction and Evaluation of Auger-Photoelectron Coincidence Apparatus at BL13 of HiSOR

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1 Introduction

Auger-photoelectron coincidence spectroscopy (APECS) combined with synchrotron radiation (SR) is the most surface-sensitive technique because the escape depth of Auger-electron detected by APECS is given by

$$\frac{1}{ED_{APECS}} = \frac{1}{\lambda_{PE} \cos \theta_{PE}} + \frac{1}{\lambda_{AE} \cos \theta_{AE}}$$

where λ_{PE} and λ_{AE} denote the inelastic mean free pass of photoelectron and Auger-electron, and θ_{PE} and θ_{AE} denote the emission angles of the detected photoelectron and Auger-electron, respectively [1]. In addition, the core-valence (CVV) APECS spectra reflect the local valence electronic states at specific surface sites if the energy-resolution of the analyzer for the photoelectron is higher than the surface core level shift [2, 3]. For these APECS measurements we have installed an electron-electron-ion (EEICO) analyzer to an ultrahigh vacuum chamber at BL13 of HiSOR.

2 Experiment

The EEICO analyzer mainly consists of a coaxially symmetric mirror electron energy analyzer (ASMA), a double-pass cylindrical mirror electron energy analyzer (DP-CMA), etc [4]. The performance of the apparatus was evaluated by measuring APECS spectra of a Si(111) surface in an ultra-high vacuum chamber with a base pressure of 4.5×10^{-9} Torr at BL13 of HiSOR. The photon energy was fixed at 130 eV. The incident angle was 86° from the surface normal. The Si(111) was cleaned by direct-current heating.

3 Results and Discussion

Figure 1 shows a wide scan Si photoelectron spectrum (PES) of Si(111) measured with the ASMA.

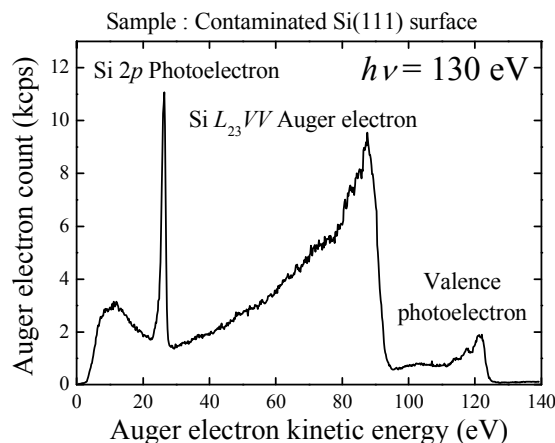


Fig. 1: Wide scan Si photoelectron spectrum of a partly contaminated Si(111) measured with the ASMA at $h\nu = 130$ eV.

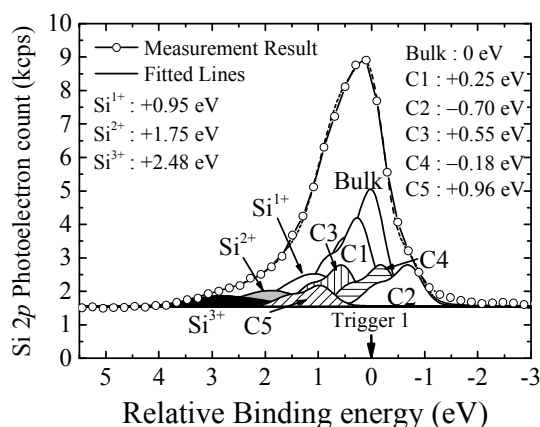


Fig. 2: Enlarged Si 2p photoelectron spectrum of a partly contaminated Si(111) measured with the DP-CMA at $h\nu = 130$ eV.

Figure 2 shows the enlarged Si $2p$ PES measured with the DP-CMA down on relative binding energy scale where the Si $2p_{3/2}$ peak of Si bulk is taken as the origin. This Si $2p$ PES is decomposed into five surface components (C1: pedestal atoms, C2: rest atoms, C3: adatoms, C4: dimers, and C5: unknown surface components), partly oxidized Si (Si^{n+} ($n = 1, 2, 3$)), and the bulk one using a well-known curve-fitting procedure [1-4]. The presence of partly oxidized Si sites suggests that the surface was partly contaminated with residual water. The Lorentzian width of 0.08 eV and Gaussian width of 0.55 eV for C1–C5 and 1.0 eV for Si^{n+} ($n = 1, 2, 3$) are used for the Si- $2p$ PES peak fitting. The spin-orbit coupling between Si $2p_{1/2}$ and Si $2p_{3/2}$ and the intensity ratio of Si $2p_{1/2}$ to Si $2p_{3/2}$ are taken as 0.6 eV and 0.5, respectively. The same procedure is applied to the Si $2p$ PES measured with the ASMA. From the fitting results, the overall energy resolution ($E/\Delta E$) of both the ASMA and the DP-CMA combined with BL13 of HiSOR is estimated to be ~ 50 . These values are nearly equal to those of the APECS apparatus at PF ($E/\Delta E = \sim 55$) [4].

Figure 3 shows a TOF spectrum of Si $L_{23}VV$ Auger electron with a kinetic energy (KE) of 88 eV measured by a multichannel-scaler by taking the bulk Si $2p$ photoelectron signal as the trigger (APECS TOF spectrum). A clear coincidence peak appears at 74.5 ± 11 ns. A series of APECS TOF spectra were measured by changing the KE of the Si- $L_{23}VV$ Auger electron. Figure 4 shows a Si- $L_{23}VV$ -Si^{bulk}- $2p$ APECS spectrum obtained by plotting the integrated coincidence counts of these APECS TOF spectra as a function of Si $L_{23}VV$ Auger electron KE (filled circles with solid line). The highest peak of Si- $L_{23}VV$ -Si^{bulk}- $2p$ APECS is shifted by ~ 1.0 eV to higher KE side than normal Si $L_{23}VV$ Auger electron spectrum (singles AES, solid line). This result indicates that the Si- $L_{23}VV$ -Si^{bulk}- $2p$ APECS spectrum mainly reflects the Si $L_{23}VV$ AES of bulk Si.

In conclusion, we constructed an APECS apparatus at BL13 of HiSOR. The performance of this apparatus

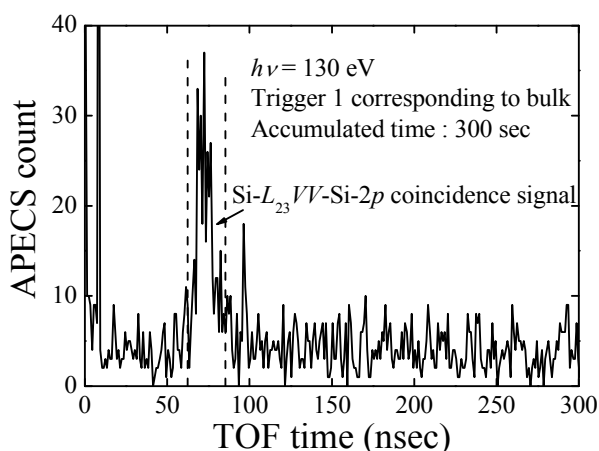


Fig. 3: APECS TOF spectrum of a partly contaminated Si(111) surface at $h\nu = 130$ eV.

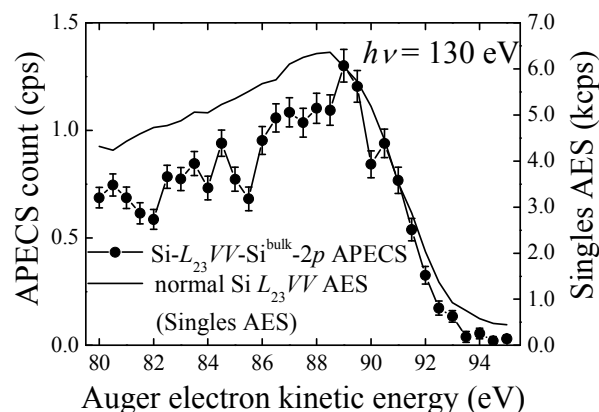


Fig. 4: PECS spectrum (filled circles) of a partly contaminated clean Si (111) 7×7 at $h\nu = 130$ eV.

such as $E/\Delta E$, the ratio of the APECS signal to the background, coincidence count rates are comparable to that of previous one developed in PF.

Acknowledgement

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References

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