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Development of an Apparatus for High-Resolution Auger Photoelectron Coincidence Spectroscopy (APECS) and Electron Ion Coincidence (EICO) Spectroscopy

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Introduction

Coincidence spectroscopy for the study of the dynamics induced by surface core-level excitations is unique and powerful technique. We have used Auger photoelectron coincidence spectroscopy (APECS), and photoelectron photoion coincidence (PEPICO) spectroscopy, and Auger-electron photoion coincidence (AEPICO) spectroscopy to investigate Auger-stimulated ion desorption mechanism [1]. APECS can be used to study local valence electronic structures of surface specific states. In 2007, we have developed an apparatus for APECS and electron ion coincidence (EICO) spectroscopy, which was named electron electron ion coincidence (EEICO) analyzer [2]. It consists of a coaxially symmetric mirror analyzer (ASMA) with an electron energy resolution (*E*/Δ*E*) of ~50, a single pass cylindrical mirror analyzer (SP-CMA) with *E*/Δ*E* of ~20, a time-of-flight ion mass spectroscopy (TOF-MS), an XYZ stage, a tilt-adjustment mechanism and a conflat flange with an outer diameter of 203 mm. To improve the *E*/Δ*E* of the SP-CMA, we have recently developed a new EEICO analyzer where the SP-CMA was replaced with a double pass CMA (DP-CMA, Fig. 1) [3]. We have evaluated the new EEICO analyzer by measuring the Si 2*p* photoelectron spectra (PES) and Si $L_{23}VV$ Auger-electron spectra in coincidence with Si 2*p* photoelectron (Si-$L_{23}VV$-Si-2*p* APECS) of Si(001)-2×1 at BL-1C.

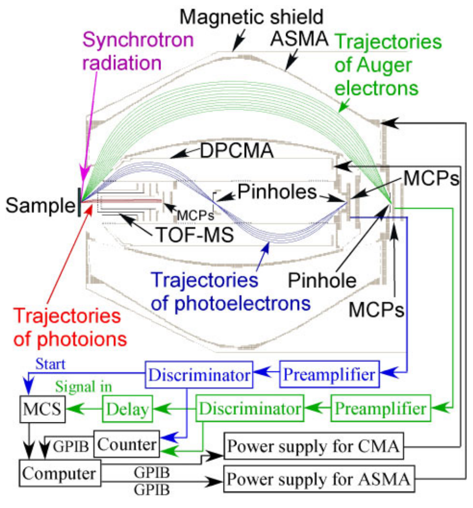

Figure 1 New EEICO analyzer for APECS and EICO spectroscopy, which consists of ASMA, DP-CMA, and TOF-MS. The measurement system for APECS is also shown [3].

Results

Figure 2 shows Si 2*p* PES of Si(001)-2×1 with (a) ASMA and (b) DP-CMA at *hυ* = 130 eV. Based on these spectra, we estimated the *E*/Δ*E* of both the ASMA and the DP-CMA to be ~50 in the kinetic energy region of 0-150 eV. Owing to the improved *E*/Δ*E* of DP-CMA, we can measure the high-resolution APECS.

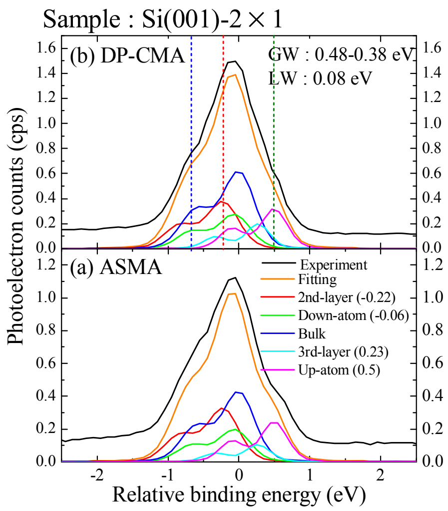

Figure 2 Si 2*p* photoelectron spectra of Si(001)-2×1 which was deconvoluted with a standard curve fitting procedure using voigt functions [3].

Figure 3 shows Si-$L_{23}VV$-Si-2*p* APECS in coincidence with Si 2*p* photoelectron from (a) Si at 2nd-layer, (b) Si up-atom of dimer, and (c) Si down-atom of dimer of Si(001)-2×1. These Si-$L_{23}VV$-Si-2*p* APECS indicates that the high kinetic energy (*KE*) side of Si $L_{23}VV$ Auger-electron spectrum (AES) corresponds to the Si up-atom of dimer. This result can be explained by the charge-transfer from the Si down-atom to the Si up-atom, because the high *KE* side of AES reflects the local valence band maximum.

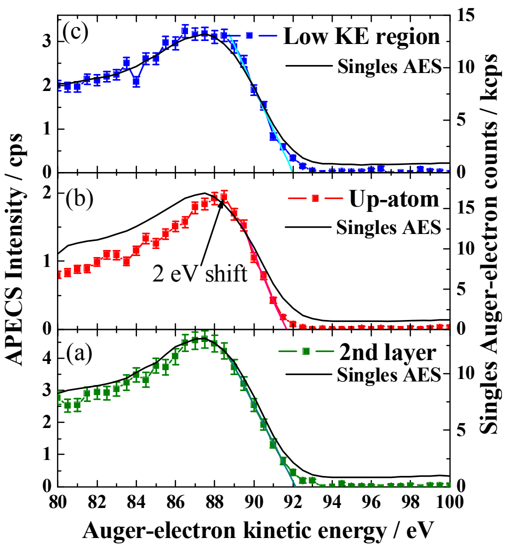

Figure 3 Surface site-specific Si-$L_{23}VV$-Si-2p APECS; (a) Si at 2nd-layer, (b) Si up-atom of dimer, and (c) Si down-atom of dimer of Si(001)-2×1 [3]. Black solid lines represent the normal Si $L_{23}VV$ AES (singles AES).

Figure 4 shows the Si-2p photoelectron spectra in coincidence with Si $L_{23}VV$ Auger-electron emission at (a) KE = 85.3 eV, (b) 87.4, and (c) 89.5 eV, respectively (Si-2p-Si-$L_{23}VV$ PEACS) of Si(001)-2×1. These Si-2p-Si-$L_{23}VV$ PEACS are deconvoluted into individual Si components based on the deconvolution shown in Fig. 2(a). The intensities of the components in the Si-2p-Si-$L_{23}VV$ PEACS are greatly different from those in the Si 2p PES. The intensity of bulk component is reduced, while that of the Si at 2nd-layer is enhanced, and that of the up-

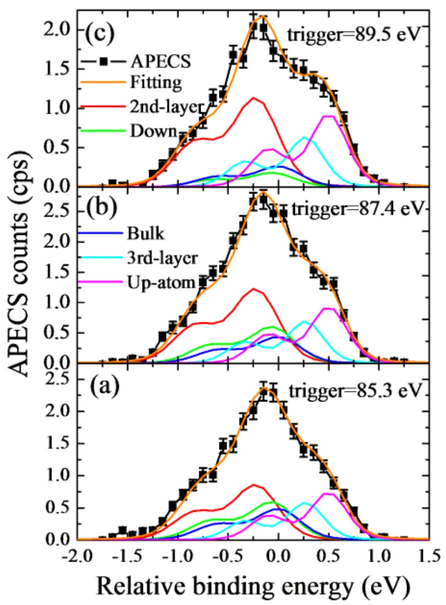

Figure 4 Si-2p-Si-$L_{23}VV$ PEACS of Si(001)-2×1 in coincidence with Auger-electron with (a) 85.3 eV, (b) 87.4 eV, and (c) 89.5 eV.

atom Si component is greatly enhanced. We estimated the escape depth (ED_{PEACS}) of Si-2p-Si-$L_{23}VV$ PEACS as ~1.3 Å. This value corresponds to the thickness of one monolayer of Si(001).

Conclusion

A new EEICO analyzer is developed and evaluated. It is now available for users of the Photon Factory. The advantages of this apparatus are high detection efficiency, high energy resolution, high surface sensitive, easy alignment, easy operation, and low cost.

References

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