Two-dimensional k-space band mapping with an angle-resolved-type time-of-flight analyzer

Manami Ogawa[1,2], Susumu Yamamoto[1], Yuka Kousa[3], Ryu Yukawa[1,2], Fumitaka Nakamura[1,2], Hiroshi Kondo[3], Yoshihito Tanaka[1,4], Iwao Matsuda[1]

1)Institute for Solid State Physics, the University of Tokyo, Japan, 2) School of Science, the University of Tokyo, 3)Faculty of Science and Technology, Keio University, Yokohama, 4) SPring-8/RIKEN

Introduction

Angle-resolved photoemission spectroscopy has been a powerful tool to directly probe band structures of materials. The energy spectrum analysis has typically been performed with a hemispherical analyzer, followed by angle and energy multi-detections with MCP, fluorescent screen, and CCD camera. An entrance slit is necessary to keep the appropriate angle/energy resolutions for this analyzer. In such a configuration, the angle-detection is limited to only one axis. Therefore, the instrument requires sample rotation for measuring two-dimensional band structures.

Recently, photoemission band mapping has been performed at synchrotron radiation (SR) beamlines with polarization-controlled insertion device or with ultrafast laser for time-resolved experiments. These measurements provide information on the symmetry of wave-functions or time-evolution of band structure of a material. However, the assignment and interpretation have been extremely complicated when such measurements are involved with sample rotation. An electron spectrometer with a different style of data acquisition has been needed.

Experiment and Result

We have developed an angle-resolved-type time-of-flight analyzer (Scienta-ARTOF) at high-brilliant soft X-ray beamline, BL07LSU in SPring-8. The light source is the polarization-controlled undualtor [1] and a femto-second laser system is installed at the beamline. The spectrometer is composed of a TOF tube with the retardation lens, MCP, and a two-dimensional delay-line detector. The analyzer is slitless, which allows the two-dimensional angle-detection of photoelectrons whose energy spectra are measured by the flight time with high efficiency. Figure 1 shows a photograph of the system at the beamline.

Figure 2 presents a part of multi-dimensional photoemission data, I (kx, ky, E), of Si(111) valence bands taken with the new analyzer. The measurement was done at photon energy of hv=250eV and it requires with no sample rotation. The photoemission band structure over the whole Brillouin zone was clearly observed and it was obtained after several hours with a SR-pulse repetition rate of 2.92 MHz (SPring-8 D-mode operation of 1/14-filling+12 bunches).

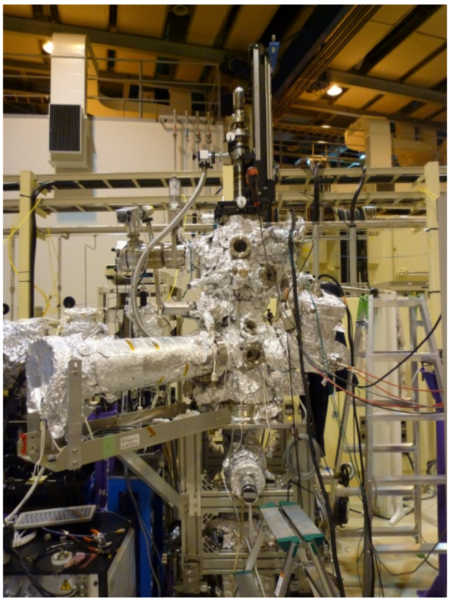

Figure 1 A photograph of the experimental UHV chamber equipped with a new angle-resolved-type time-of-flight analyzer (Scienta-ARTOF). The system is installed at SPring-8 BL07LSU.

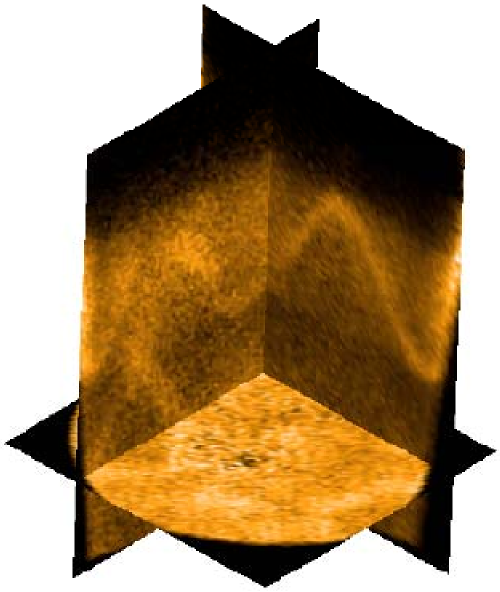

Figure 2 A demonstration of two-dimensional band mapping of the Si valence band. A part of the multi-dimensional data is shown. The wave vector range is +/- 1.5 $Å^{-1}$ and the energy region is 17.5 eV.

Conclusion

A new angle-resolved-type time-of-flight analyzer (Scienta-ARTOF) was developed at high-brilliant soft X-ray beamline, BL07LSU in SPring-8. A demonstration of the two-dimensional photoeemision band mapping of the Si(111) valence band was successfully performed.

Reference

[1] Y. Senba, S. Yamamoto, H. Ohashi, I. Matsuda, M. Fujisawa, A. Harasawa, T. Okuda, S. Takahashi, N. Nariyama, T. Matsushita, T. Ohata, Y. Furukawa, T. Tanaka, K. Takeshita, S. Goto, H. Kitamura, A. Kakizaki, M. Oshima, Nuclear Instruments and Methods in Physics Research Section A, in Press.