Photoelectron Momentum Microscope at IMS

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The demand for photoelectron micro-spectroscopy and spectro-microscopy to characterize the electronic properties of microstructures is growing rapidly. Photoelectron spectroscopy resolved in three-dimensional momentum space with a microscopic field of view is realized by combining a so-called Momentum Microscope (MM) with a soft X-ray synchrotron radiation source. We built a new MM station at BL6U,[1] an undulator-based soft X-ray beamline. This station opens the door to direct observation of the Fermi surface of μm-sized crystals, which was difficult with conventional ARPES-type hemispherical analyzers.

1. Momentum Microscope

As shown in Figure 1, the system consists of a photoemission electron microscope (PEEM) lens, a hemispherical deflection analyzer as an imaging-type energy filter, and a 2D detector with a CMOS camera. The details of the specification evaluation result are described elsewhere.[1] In brief, the energy resolution of the analyzer was estimated to be 20 meV at pass energy of 20 eV. The spatial resolution in the microscopy mode was evaluated to be about 50 nm. The momentum resolution of 0.012 $Å^{-1}$ has been achieved. The position of sample stage facing to the analyzer is precisely controlled by a hexapod. Samples can be cooled down to 8 K and heated up to 400 K.

Since a high voltage is applied between the sample and the PEEM lens, it is essential that the sample be flat. We have developed a technique to cleanly cleave sub-mm-sized crystals in the ultra-high vacuum condition. Figure 2 shows a valence band measurement with a wide **k** acceptance of 6 $Å^{-1}$ in diameter.

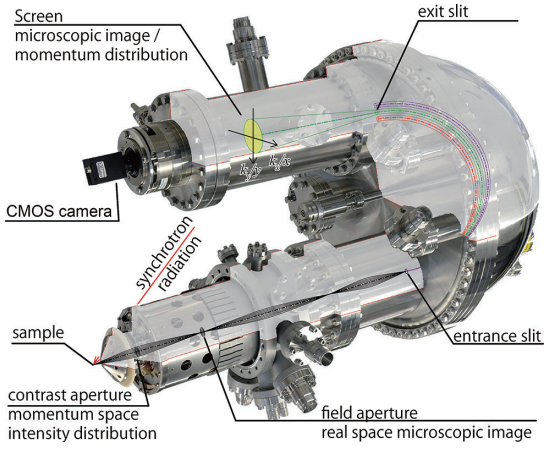

Figure 1. Schematic drawing of the momentum microscope.[1]

2. Original Electron Analyzers

Furthermore, we are aiming at highly efficient and comprehensive measurement of spin distribution as the final goal. *Omnidirectional photoelectron acceptance lens* (OPAL)[2] together with *Projector for electron spectroscopy with collimator analyzer* (PESCATORA)[3] enables photoelectron holography measurement of the full hemisphere. Moreover, we invented *Right angle deflection imaging analyzer* (RADIAN)[4] for spin vector analysis with ***k***/***r***-space resolution. We are expanding the MM system based on our original device developments.

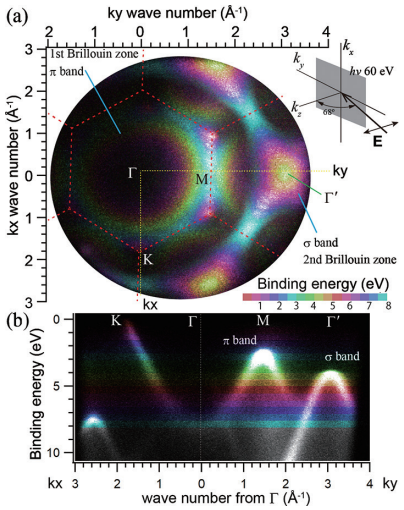

Figure 2. (a) Photoelectron angular distribution and (b) band dispersion of the cleaved graphite crystal surface.

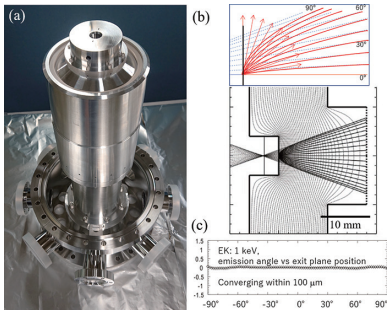

Figure 3. (a) Photograph of the omnidirectional photoelectron acceptance lens (OPAL). (b) 1-keV electron trajectory at the sample surface. (c) Performance of electrons emitted in full hemisphere.[2]

References

1) F. Matsui *et al.*, *Jpn. J. Appl. Phys.* **59**, 067001 (2020).
2) H. Matsuda and F. Matsui, *Jpn. J. Appl. Phys.* **59**, 046503 (2020).
3) F. Matsui and H. Matsuda, US Patent 10614992 (2020.04.07).
4) H. Matsuda and F. Matsui, Patent submitted (2020.07.09)