Dual-beamline photoelectron momentum microscopy upgrade advances valence orbital analysis

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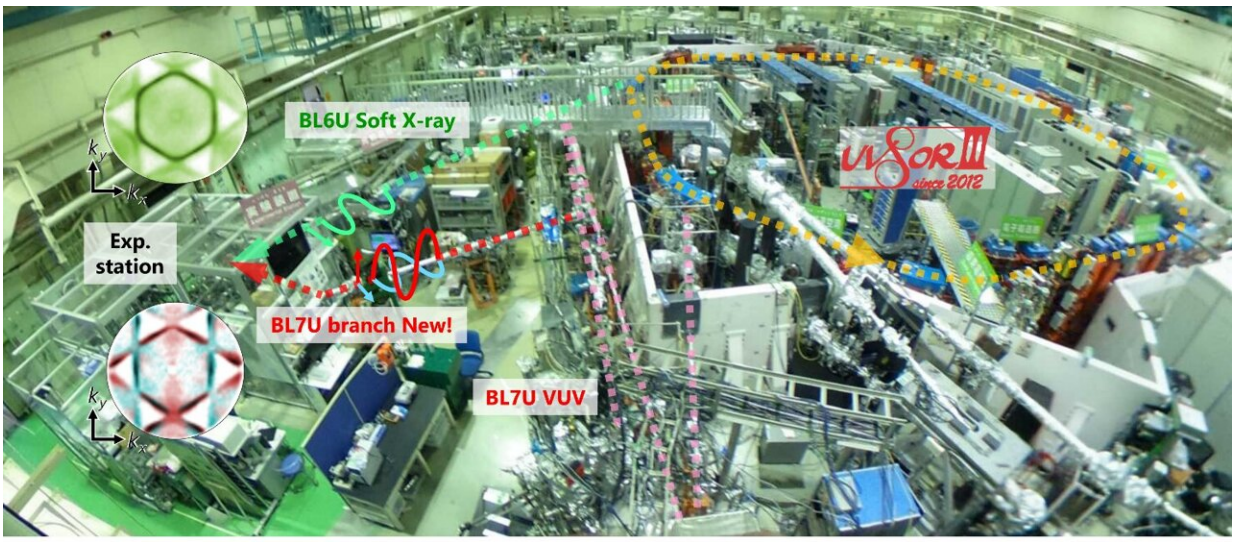

Beamlines BL6U, BL7U, the newly constructed BL7U branch, and electron storage ring are highlighted in dotted lines. The upper (lower) left inset shows the photoelectron momentum pattern of the Au(111) surface measured using BL6U (the BL7U branch). Credit: Prof. Fumihiko Matsui Group, Institute for Molecular Science

The world's first dual-beamline photoelectron momentum microscope has been developed at the UVSOR Synchrotron Facility, Japan. This innovative experimental station brings breakthroughs in studying the

behavior of electrons in materials governing material properties, particularly in analyzing valence orbitals.

Understanding the behavior of electrons in materials is crucial for the advancement of materials science and device engineering. Conventional photoelectron spectroscopy provides deep insight into the nature of the electronic structure of solids. Currently, the challenge of researching electronic structures on the micrometer scale is being pursued all over the world.

A state-of-the-art momentum-resolved photoelectron spectroscopy apparatus with additional microscopic function, called "photoelectron momentum microscope," was constructed at the UVSOR Synchrotron Facility, Institute for Molecular Science, Japan, revolutionizing micrometer-scale analyses of the behavior of electrons.

Researchers from Institute for Molecular Science / The Graduate University for Advanced Studies, SOKENDAI in collaboration with Osaka University have upgraded this advanced analyzer and experimental station to use two undulator beamlines as excitation sources. By branching the existing vacuum ultraviolet (VUV) beamline BL7U, VUV light has now become simultaneously available at the photoelectron momentum microscope in addition to a soft-X ray beam from the beamline BL6U. The work is published in the *Journal of Synchrotron Radiation*.

This world's first "dual-beamline photoelectron momentum microscope" allows 1) element selective measurements using the grazing-incidence soft X-ray light and 2) highly symmetric measurements using the normal-incidence VUV light. Taking advantage of the flexibility of these light sources creates a new pathway for multimodal analyses of the behavior of electrons.

Photoelectron spectroscopy in the normal-incidence configuration is only available with this apparatus at UVSOR worldwide. Highly symmetric configuration with such normal incidence facilitates precise analyses of valence orbital via photon polarization-dependent transition-matrix-element analysis. In this work, the researchers applied this approach to the valence electrons of the Au(111) surface.

This unique dual-beamline photoelectron momentum microscopy offers deeper insights into the behavior of electrons in materials, innovating fields of condensed matter physics, molecular science, and materials science.

UVSOR synchrotron facility

UVSOR is a synchrotron radiation facility at Institute for Molecular Science, Japan with the world's highest performance in the extreme ultraviolet energy range and is widely used by domestic and overseas researchers. The extreme ultraviolet energy range is suitable for observing behavior of electrons which are responsible for properties of molecules and solids.

Synchrotron radiation emitted from an electron storage ring with a circumference of about 50 meters is introduced into more than a dozen experimental stations in which a wide variety of researches on bioscience, environmental and energy sciences as well as physical and chemical sciences are conducted. Although it is the second oldest synchrotron radiation facility in Japan since the first light was observed in 1983, it successfully maintains state-of-the-art performance through undergoing intensive upgrades twice.

More information: Kenta Hagiwara et al, Development of dual-

beamline photoelectron momentum microscopy for valence orbital analysis, *Journal of Synchrotron Radiation* (2024). DOI: 10.1107/S1600577524002406

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