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Photoelectron Momentum Microscopy(PMM) and Sot X-ray Resonant Inelastic Scattering(SX-RIXS) with spatial resolution down to sub-μm scale and prospect of their operand measurements

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Angle resolve photoelectron spectroscopy(ARPES) is a very powerful approach to clarify the electronic structures of conductive materials. However, the sample rotation was usually employed to cover the wide (kx,ky) region. Then the selection rules changes and often the probed regions on the surface shifted slightly. The low detection efficiency of the conventional ARPES also induced the surface radiation damages to get reasonable statistics, spoiling the quality of the obtained results.

To solve these serious problems, photoelectron momentum microscope (PMM) was developed in early 2010th. When I met with this approach in the Kirschner's Lab in Max-Planck-Institute for Microstructure Physics, Halle in 2013, I recognized its high potential. By the high extraction voltage between the sample surface and the PEEM type objective lens up 15 or 20 kV, the whole photoelectrons emitted into 2π steradian can be simultaneously recorded by the 2D detector in the case of Ek up to ~70eV. Then the ARPES efficiency becomes orders of magnitude higher by PMM than the conventional ARPES.

In addition, effective spin detection is feasible by use of 2D Au/Ir(001) spin filter at low electron kinetic energy (10.25 and 11.50eV) with FoM of around 10^2. Then the spin detection efficiency becomes around 5 million times higher than the Fe-O VLEED single channel detection.

Since we have installed the PMM at UVSOR BL6U+BL7U we can now perform E_B(kx,ky,kz) PMM not only at 68° incidence but also normal incidence for the 1st time in the world. The selection rule dependence of the E_B(kx,ky,kz) is now measurable and theoretically analyzable. Within this year, we will install this spin filter and start SP-PMM in UVSOR, Okazaki, Japan. The sub-μm resolution without any sample movement and radiation damage will provide us useful and reliable information for device development. We will soon start measurements of magnetized samples as well as samples under electric field and uniaxial strain.

On the other hand, non-conductive materials should be studied by other method. Soft X-ray resonant inelastic scattering (SX-RIXS) combined with theoretical analyses can provide rich information on electronic states. Operando measurement is feasible under the magnetic field, electric field as well as under a uniaxial strain. Since this technique is bulk sensitive, the focusing of the soft X-ray smaller than 1μm facilitates the reliable measurement.

By combining these techniques with spin-STM/STS and ToF-SP-PMM, we would like to study complete electronic states of operand device in the μm scale.

1. Photoelectron Spectroscopy: Bulk & Surface Electron Structures. Springer Series in Surface Sciences **72**, 1~511. 2nd edition(2021). S.Suga, A.Sekiyama and C.Tusche.