# 第80回フロンティア材料研究所講演会
# 80th MSL Lecture

**Date/Time:** 14:00 – 15:30, Monday, November 12th

**Venue:** 1F Meeting Room, Building R3

**Speaker:** Prof. Shigemasa SUGA

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## Frontier of Photoelectron Spectroscopy and Resonance Inelastic X-ray Scattering in Solids

High resolution & multi-dimensional spin- & angle-resolved photoelectron spectroscopy (ARPES) in micro-nano regions is required in recent years for both fundamental researches and device development. However, extremely low spin detection efficiency has so far hindered its progress.
Development of the momentum microscope (M.M.) composed of a PEEM type input lens and aberration corrected tandem S-type double hemispherical deflection analyzers (DHDAs) has opened a breakthrough. 2D $E_B(k_x,k_y)$ can be simultaneously measured in a very wide **k** space with such high resolutions as $\Delta E<12$ meV & $\Delta k < 0.005$ Å$^{-1}$. Nearly $10^4$ $(k_x,k_y)$ points can be measured over a wide surface/bulk Brillouin zones (BZs) at the same time for a certain $E_K$(or $E_B$),which is then scanned.
Long life time 2D imaging spin filter such as Au/Ir(001) can be installed behind this M.M. Then spin-asymmetric 2D $E_B(k_x,k_y)$ images can be recorded at two electron incidence energies (10.25 & 11.5 eV) with about ±60% spin sensitivity. From these two spectra, spin resolved spectrum in the wide **k** space is easily derived in the form of $P_s(E_B(k_x,k_y))$. Even 3D $P_s(E_B(k_x,k_y,k_z)$ is obtained by changing the hν. Since the PEEM can collect electrons emitted into wide solid angles, 2D multi-channel figure of merit (FoM) of this spin detection is ~millions or ~billions times higher than the single channel Fe-O VLEED spin detector or Mott and spin-LEED spin detector.
Examples of surface Rashba states as well as Dirac cone states of topological insulators are presented, showing the necessity of experiments by M.M.
Although detailed knowledge of the electronic structures in non-conductive materials is desired nowadays, (AR)PES cannot be applied because of the charging up effects. In such a case, photon-in/photon-out experiment as RIXS is ideal. Here the micro-nano study requires the focusing of the excitation synchrotron radiation. Still the surface radiation damage is not serious because RIXS is really bulk sensitive. Great advantage of RIXS is the feasibility of measurements under any external perturbations. Standard RIXS of V and Cr oxides as well as RIXS of half metal Heusler alloy $Mn_2VAl$ under external magnetic field are discussed.
In both cases, advanced theoretical calculations based on the 1st principles band calculations and 1 step model calculations of the photoelectron spectra fully taking into account the experimental configurations and/or the intermediate states are required. Intense collaborations between experimentalists and theoreticians are now demanded for reliable understanding of the full data sets of experiments.

References

1. S.Suga and C.Tusche, Photoelectron spectroscopy in a wide hν region from 6 eV to 8 keV with full momentum and spin resolution, J.Electron Spectrosc. Rel. Phenom. **200**, 119-142 (2015)
2. S.Suga and A.Sekiyama, Photoelectron Spectroscopy: Bulk and Surface Electronic Structures, Springer Series in Optical Sciences **176,** 1-378 (2014).
3. K.Nagai, H. Fujiwara, S. Suga, R. Y. Umetsu et al., Phys.Rev.B**97**, 035143 (2018).

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